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GOSH!

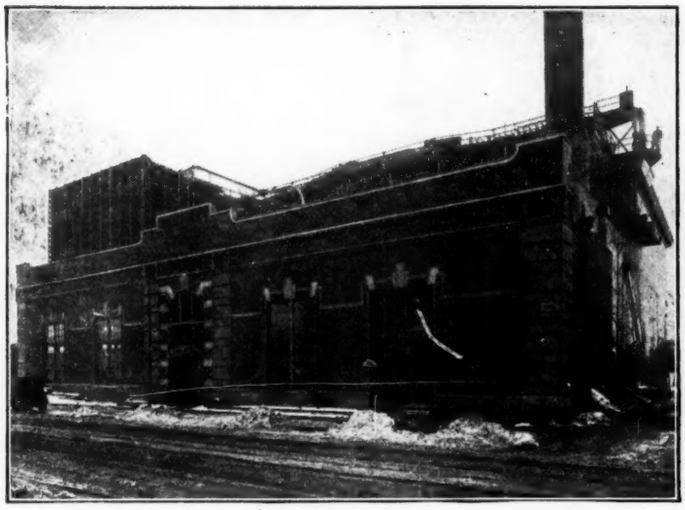


FIG. 1. FINNEY AVENUE PLANT OF THE MERCHANTS ICE AND COAL CO.

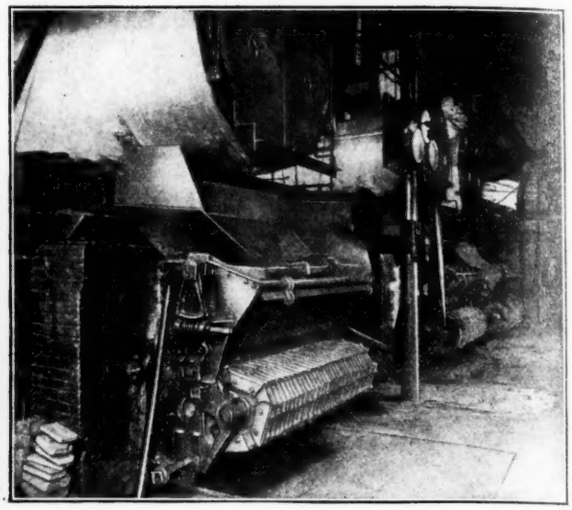


FIG. 2. THREE 200-HP. STOKER-FIRED BOILERS, FINNEY AVENUE PLANT

Economy at the Finney Avenue Ice Plant, St. Louis

By C. WILKIE
Engineer, Finney Avenue Plant, Merchants Ice and Coal Co., St. Louis, Missouri

A refrigerating plant fourteen years old with mediocre equipment is operating at 58.6 per cent over its rated capacity and is delivering on the average 8.5 tons of ice per ton of 10,000-B.t.u. coal. Ingenuity of the management, co-operation of the operating force and careful manipulation of the equipment are the reasons advanced for the splendid showing.

THE Finney Avenue Plant of the Merchants Ice and Coal Co., St. Louis, is not a modern steam-driven plant. There are no boilers with 80 per cent efficiency, no uniflow engines using 12 lb. of steam per indicated horsepower-hour and no superheated steam, but the plant ranks with a number of others having the most modern equipment. It has been in operation for fourteen years and was one of the first in the country to make raw-water ice with any degree of success.

Its capacity up to 1908 was 150 tons of ice per day plus the refrigeration for the ice-storage rooms. Since that time the capacity has been increased to 238 tons plus the ice storage. The increase was obtained without adding to the boiler equipment or ice-making machinery, without the assistance of extra coils on the freezing system or additional ammonia-condenser surface. Efficient and careful operation of the equipment available, improvements where possible and labor-saving devices are the reasons back of the higher economy and greater capacity obtained.

Boiler, engine and ice-storage rooms are on the ground floor of the plant. The steam-condenser cooling tower is located on the engine-room roof. It is of the open flat type, with the breaks on 16-in. spacing. The primary ammonia condensers are located on top of the tower previously mentioned, and the freezing tanks are just above the ice-storage rooms. The secondary ammonia condensers, liquid-cooling coils and ammonia-condenser cooling tower are on the roof above the freezing-tank room.

In the boiler room are three 200-hp. combination fire- and water-tube boilers, equipped with chain-grate stokers. This type of boiler has the reputation of being troublesome, owing to leaky flues, but this difficulty has been overcome in a measure by careful firing, maintaining the load as nearly constant as possible and by protecting the rear flue sheet.

When two of the units are in service, the boilers are operated at high capacity, but with three on the line the load on each is below rating. From the daily ice production it is evident that the losses sustained are very small.

To furnish necessary operating data, the boilers are equipped with draft gages, CO_2 recorders and a damper regulator. The device last named is set so as to reduce the draft about one-half when closed and at the same time slow down the stoker engine in proportion to the reduction in draft. Coal, which is hauled to the plant by motor trucks and dumped in the alley, is conveyed into the boiler room by a bucket conveyor.

There are two vertical single-acting ammonia compressors, with cylinders 20 x 30 in. driven by tandem-compound Corliss engines, the latter being supplied with steam at 160 lb. pressure at the throttle and 10 lb. on the receiver. During the summer months the machines are operated at 80 r.p.m., an unusually high speed for their size and type, when it is considered that 65 to 70 r.p.m. is the usual thing. The average condenser pressure during this period is only 170 lb., as compared with 215 lb. in other plants in the same locality. Under the

conditions enumerated, the horsepower developed in either case would be practically equivalent, but with the lower condenser pressure and higher speed, more refrigerating capacity would be developed.

The generating units consist of two 870-ampere, 110-volt, direct-current machines, one a reserve unit, directly connected to cross-compound four-valve engines. All the engines exhaust into a surface condenser on which a vacuum of from 23 to 26 in. is maintained. The vacuum pump is of the late feather-valve flywheel type and is motor-driven.

An interesting feature of the plant is the small number of steam-driven pumps in operation. There are only four in the plant, two $5\frac{1}{4}$ x $4\frac{3}{4}$ x 5-in. pumps for supplying distilled water, with two in reserve as auxiliaries. For supplying air to the raw-water freezing tanks there is a low-pressure rotary blower with a displacement of 900 cu.ft. per min. at 2 lb. pressure, belted to a 15-hp. motor, and a centrifugal compressor having a capacity of 1,600 cu.ft. per min. at 2 lb. pressure, directly connected to a 20-hp. motor. The latter machine is of the high-speed type, making 3,400 r.p.m.; the speed of the blower is 550 r.p.m. One of these units is held in reserve. Air for general purposes and especially for the ice cranes in the freezing-tank room is furnished by a $10\frac{1}{2}$-in. cross-compound steam-driven air compressor, with a 9-in. compressor of the same type held in reserve. The exhaust steam from the two compressors is used for the purpose of heating the bath water, and all of the excess goes to the boiler-feed water heater, thus utilizing practically all of the heat.

All water for freezing and condenser cooling purposes is supplied from the city mains through a 3-in. line. Two 1,000-g.p.m. centrifugal pumps, each direct connected to a 40-hp. motor, circulate the cooling water for the steam condenser, the steam-condenser tower and the primary ammonia condenser. The two pumps are located in the engine room near the steam condenser, and with a supply tank located on a balcony directly above, the water flows through the steam condenser to the pump and is forced to the top of the steam-condenser tower. The water level in the supply tank being about 14 ft. above the pumps, reduces the actual head against which they must operate. In addition the suction and discharge lines to the pumps are extra large to reduce the loss due to pipe friction.

Cooling water for the secondary ammonia condenser is circulated by a 3,000-g.p.m. centrifugal pump, also direct connected to a 40-hp. motor. This pump is located 31 ft. below the top of the ammonia-condenser coils and at one end of the ammonia condenser tower. The water from the tower flows across the roof to a supply tank placed three feet above the pump. Although suction and discharge connections of the pump are 12 and 10 in., the respective pipe lines are 20 and 18 in. in diameter.

Metallic packing is used on all valve stems, as well as on the steam-piston rods and ammonia-compressor rods, so that rod trouble in the plant is reduced to a minimum.

An interesting feature is the arrangement of the three freezing tanks. These are 79 ft. long and have

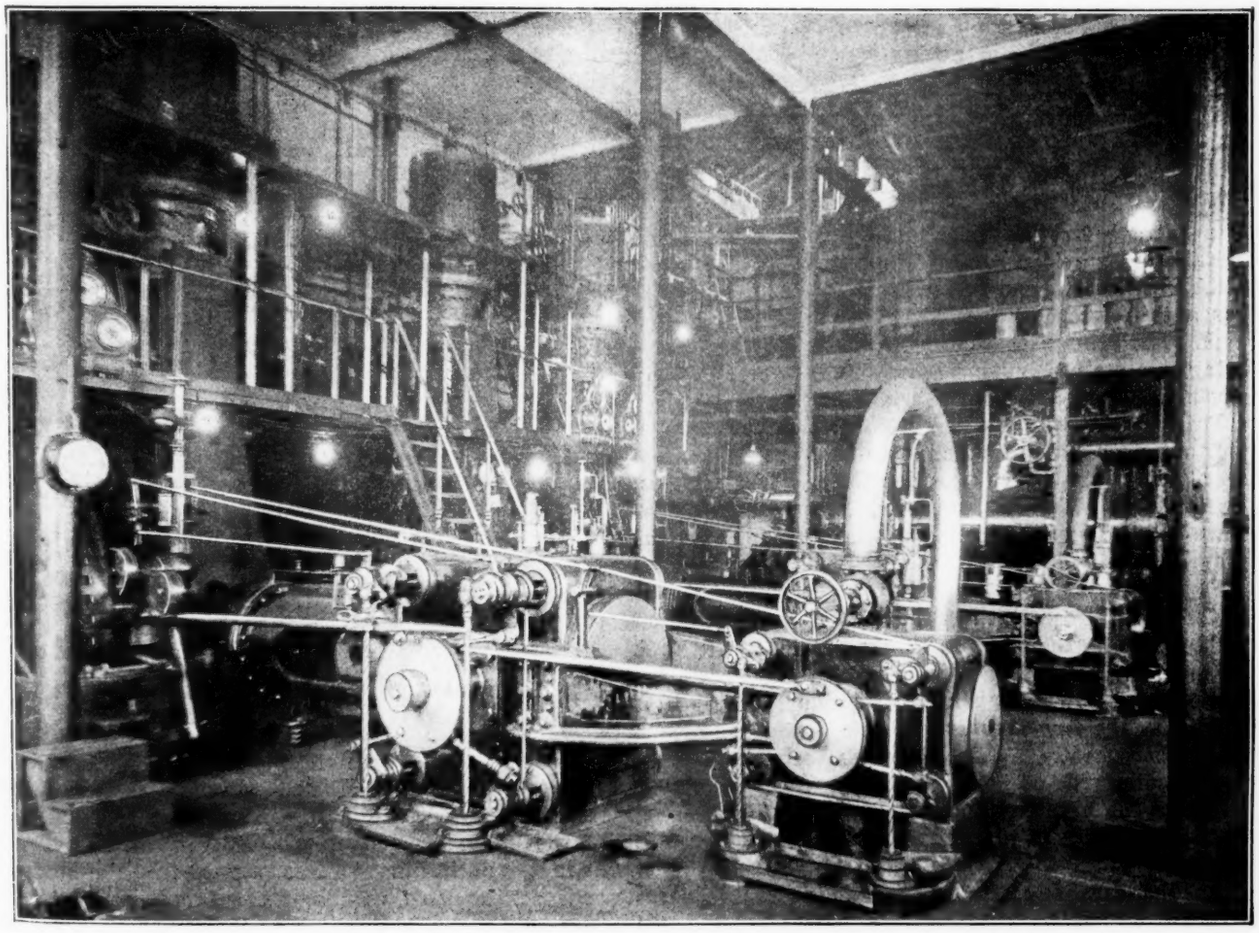


FIG. 3. TWO VERTICAL SINGLE-ACTING AMMONIA COMPRESSORS DRIVEN BY TANDEM-COMPOUND CORLISS ENGINE

sufficient width for eighteen 400-lb. cans. Each tank contains twenty coils of 1¼-in. pipe, three of the coils on either side being 12 pipes high and the other fourteen coils, 10 pipes high. The total number of cans is 1,818, giving an allowance of 7.6 cans per ton of ice.

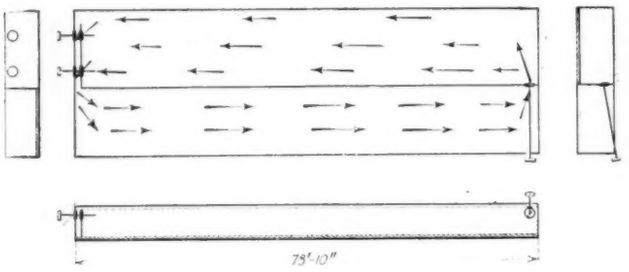


FIG. 4. ICE TANK WITH THREE PROPELLERS FOR RAPID BRINE CIRCULATION

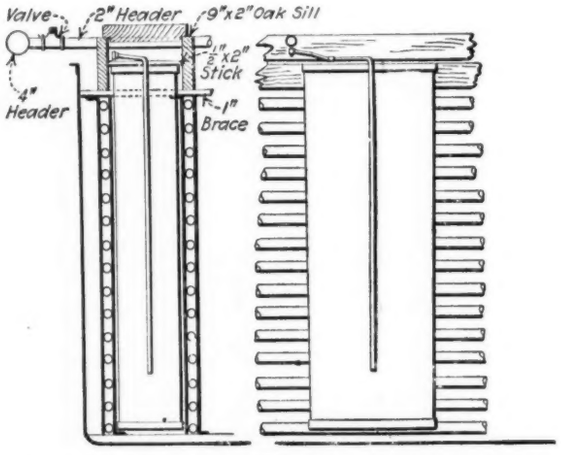


FIG. 5. DROP PIPE SYSTEM FOR AGITATING RAW WATER IN CANS

The average freezing time is 36 hr. 35 min. Brine agitation is provided for by two horizontal belted propellers in the rear end of each tank, although one tank has a third propeller located in the front end of the tank. The brine circulation is rapid, 4½ in. of agitation being maintained during the summer months and amounting to one inch for every 7½ cans.

Particular attention is called to the manner in which the tank floor is arranged so as to keep the brine from overflowing into the ice cans, due to the high agitation. The tank is divided longitudinally, the brine circulating down one side and returning on the other side to the propellers.

Fig. 4 shows the general arrangement, but includes the third propeller and the false flooring on both sides. As the brine leaves the propellers, its level, as previously mentioned, is raised 4½ in. above the stationary level of the brine, and gradually recedes to normal as the flow approaches the opposite end of the tank; consequently, a false floor has been provided on the outgoing side of the tank, its elevation being four inches at the high end and receding to zero at the end of the tank opposite to that in which the propellers are located.

As the cans are 60 in. high and the ice blocks measure 53 in., there is sufficient range so that the brine level need not be pulled down below the ice on the low side nor forced over the top of the cans on the high side.

The three-propeller tank is so arranged that each side of the tank has high brine, but on opposite sides and ends. The two motors that drive the three propellers are connected to the same starting box, so that if a fuse should blow or there should be any mishap to the box, all three propellers would stop, for the simple reason that the agitation in this tank is much more rapid than in the other two tanks. The one propeller in the front end of the tank is designed to handle as much brine as the two in the rear end. Since the third agitator was put into operation, it is easy to get three tons of ice more per day than on either of the other two tanks with the same brine temperature and the same number of cans.

For agitating the raw water in the cans, a drop-pipe system is employed. A 4-in. header on either side of the tanks, with 2-in. headers connected at right angles,

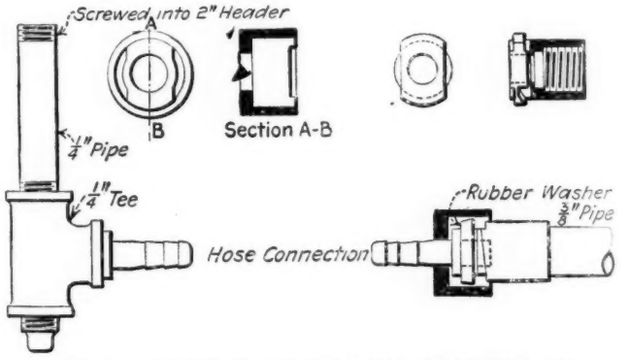


FIG. 6. FITTINGS CONNECTING DROP PIPE TO AIR HEADER

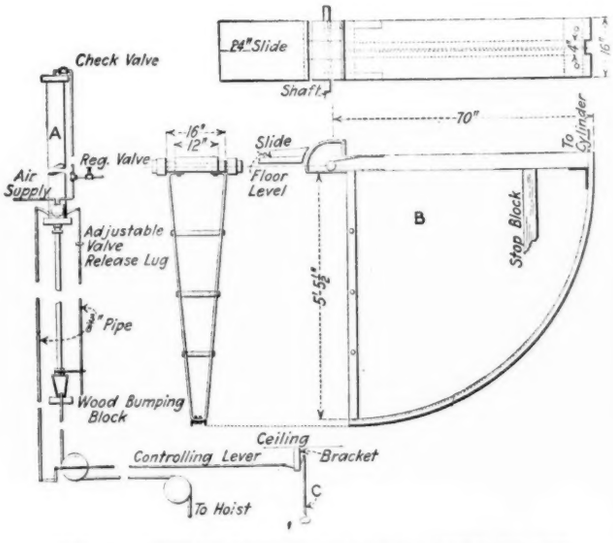


FIG. 7. DEVICE FOR UP-ENDING CAKES OF ICE

serves to distribute the air to the cans. These headers are under the tank covers and between every other row, making it necessary for the ice pullers to siphon ahead of the pulling so as to have air connections. Brass fittings ⅜ in. in diameter are screwed into the headers, and each is fitted with a piece of hose seven inches long with a special coupling at the far end. The drop pipe, which is made up of ⅜-in. galvanized pipe and

extends to within nine inches of the bottom of the can, is connected to the hose by a quarter turn on the coupling.

Owing to the high brine agitation the cans tend to rise. To keep them down in the brine, slots $\frac{5}{8}$ in. wide and $\frac{3}{8}$ in. deep have been made in the deck boards or sills and a 1 x 2-in. pine stick, beveled at either end, is placed over the can. The stick serves also as a support for the drop pipe. There is about 1 to 1½ per cent of white ice due to air trouble. During the winter months exhaust steam passing through a coil in the air receiver serves to heat the air from 80 to 130 deg. F.

The ice cranes are of the pneumatic bridge type arranged to handle three cans at one time. Three automatic lowering machines with the necessary chutes deliver the ice from the dumps to any location in the storage rooms, where only one man is required for taking care of the ice when it is being stored.

A machine has been perfected for standing the blocks of ice on end. It is operated by air and takes the place of one man on each shift. The device consists of an air cylinder *A*, Fig. 7, which by means of a cable connection to the quadrant *B*, up ends the block of ice and causes it to pass down a low incline to the floor level. The piston is actuated by means of rod *C*, which opens the valve and allows the air pressure to push the piston toward the top of the cylinder, pulling the quadrant and the cake of ice on its upper platform through an angle of 90 degrees.

An adjustable release lug on the $\frac{3}{8}$-in. pipe connecting with the valve lever is so located that when the bar of iron on the crosshead comes in contact with it, the valve lever is raised, reversing the direction of the piston and allowing it and the quadrant to return automatically to the normal position ready for another cake of ice. When the ice puller dumps the ice on the second floor, the automatic lowering machines, with the aid of chutes, deliver each cake of the 238 tons pulled each day within four to six feet of this machine, except when the permanent ice storage is being filled. At the plant the ice-storage capacity is only 3,500 tons, but other storage houses are provided in various residential sections of the city, which are filled from the plant during the winter months.

Wher. this machine was first installed, the upper end of the cylinder was open to the atmosphere and the

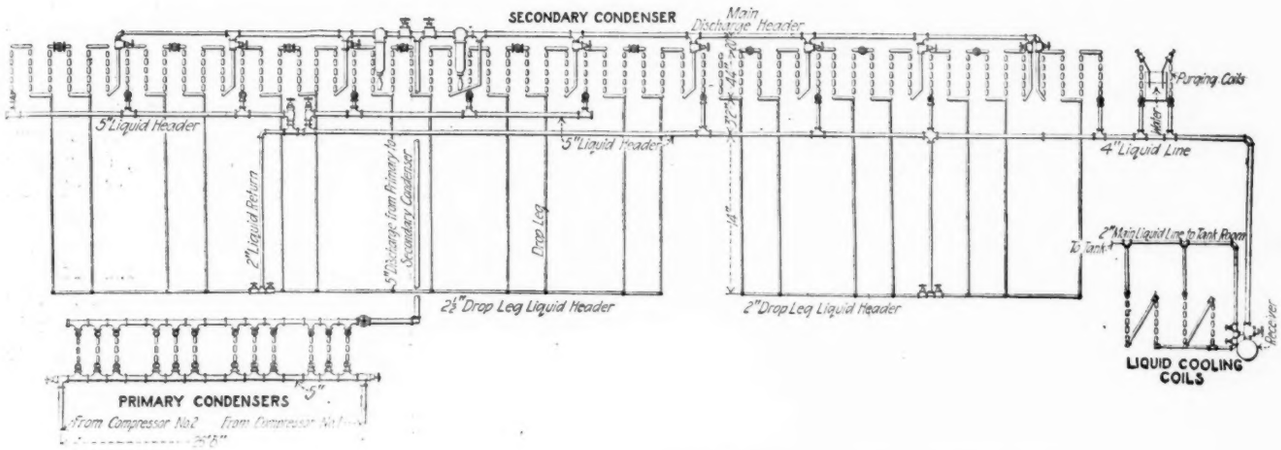


FIG. 8. CONNECTIONS OF PRIMARY AND SECONDARY AMMONIA CONDENSERS

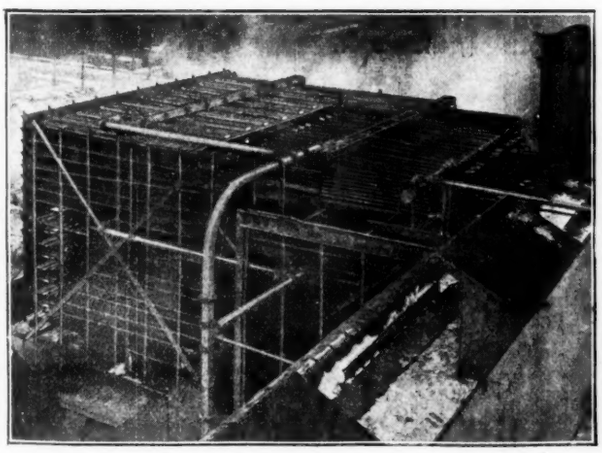


FIG. 9. STEAM CONDENSER COOLING TOWER AND PRIMARY AMMONIA CONDENSER

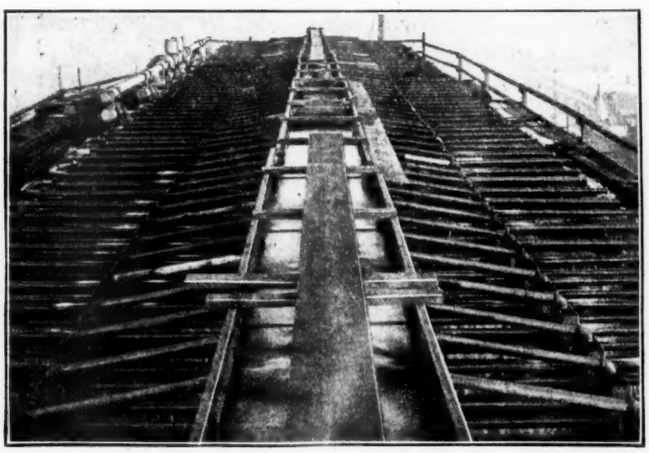


FIG. 10. TOP VIEW OF THE SECONDARY AMMONIA CONDENSER

piston would come up so rapidly and with such force that it would throw the cakes of ice several feet away. This trouble was overcome by connecting the discharge into the top of the cylinder, with a regulating valve on the line and a check valve near the top of the cylinder.

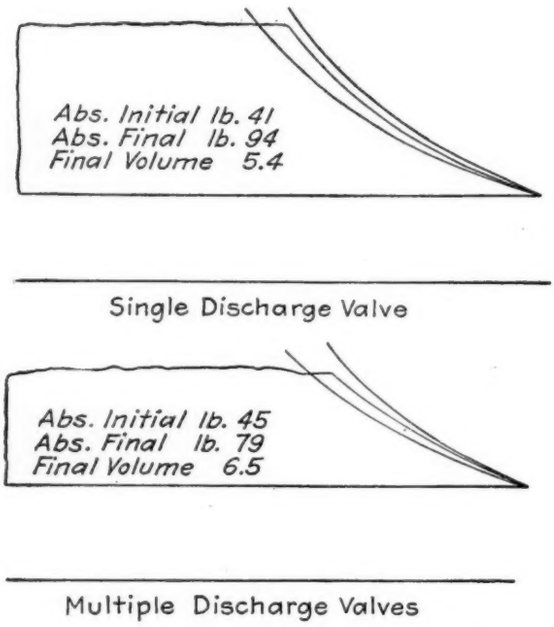


FIG. 11. AMMONIA-COMPRESSOR DIAGRAMS

Now when the piston makes its downward stroke, the air is discharged into the top end of the cylinder through the check valve and by the piston on its upward stroke is discharged through a $\frac{1}{16}$-in. hole in the disc of the check valve. This, of course, serves to cushion the piston and at the same time slows down the machine as the cake of ice is nearing its vertical position.

The ammonia condensers are of particular interest. They are divided into two sets, as shown in Fig. 8. The primary condenser, consisting of twelve stands, eight pipes high, of 2-in. pipe 20 ft. long, is located on top of the steam condenser tower. During the summer months the cooling water is about 120 deg. F. The secondary condenser is located on top of a vertical-blade, open-type cooling tower, the blades being 20 ft. high and one under each coil. The average difference in cooling-water temperature on and off the coils is three degrees. Just over the liquid cooling coils is a flat open-type cooling tower. After cooling water has passed through the vertical blade tower, the quantity necessary for the liquid coils passes through this tower and receives a second cooling before going over the coils. In this way a ten-degree drop in the liquid between the receiver and the expansion valves is obtained.

A feature of the condenser installation is the extremely low pressure maintained during the winter months. Fig. 11 shows typical ammonia-compressor diagrams. The upper diagram shows about the average conditions under which the compressors operate during the winter months, and at times when the weather is favorable, the conditions indicated in the lower diagram obtain. To maintain this low condenser pressure requires considerable attention. The water leaving the cooling tower must be a few degrees above, yet as near the freezing point as possible, so that ice will not accumulate in the tower. The water temperature is regulated by turning water on or off the coils, depending upon outside temperature of the water leaving the tower.

With one compressor in operation 170 tons of ice per day can be made during the winter months. This gives an allowance of 10.7 cans per ton and a 52-hour freezing rate. The compressor displacement per ton per minute during the summer will average 11,850 cu.in., while in the winter it is as low as 8,500. The ice production per ton of coal will average $8\frac{1}{2}$ tons, the coal used being No. 3 washed nut with a heat value of 10,000 to 10,500 B.t.u. A summary of ice-tank performance is given in the accompanying table:

ICE-TANK PERFORMANCE

Number of cans, 400 lb.	1,818
Tons of ice per day	238
Average can allowance per ton	7.6
Lineal feet, 1¼-in. pipe	57,000
Lineal feet, 1¼-in. pipe per ton of ice	239
Average suction pressure, lb.	20.5
Average brine temperature, deg. F.	12
Temperature corresponding to suction pressure, deg. F.	7
Temperature difference, deg. F.	5
Surface external pipe, sq.ft.	24,800
Tons refrigeration per 24 hours	266.9
B.t.u. per 24 hours ice cooling and freezing	76,892,000
B.t.u. per square foot per hour	129
K-heat transmitted per deg. temperature difference per square foot per hour	25.8

All the data used in this article were gathered by the writer during the season of 1919 and are averages for the 135 days from June 2 to Oct. 15.

Seven of the principal reasons why the plant production is 58.6 per cent over its rated capacity are as follows:

Remarkable ingenuity shown by E. S. Ormsby, vice-president and general manager, and A. Gass, chief engineer.

Co-operation of the employees throughout the plant.

The low condenser pressure maintained.

The excellent ice-tank performance.

The increased speed of the ammonia compressors.

Constant operation of the plant during the summer months.

The small amount of re-expansion of gas in ammonia-compressor cylinders.

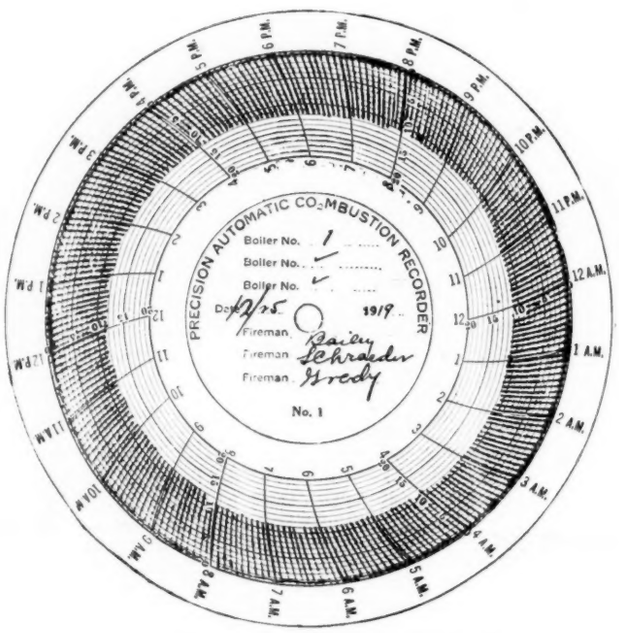


FIG. 12. CHART FROM CO_2 RECORDER INDICATING CAREFUL FIRING ON A CONSTANT LOAD

Steam-Jet Air Pumps for Condensers

The Problem of Air Removal From Condensers and the Various Methods of Solving It—A Description of Various Makes of Steam-Jet Pumps Designed for Condenser Work—Some Points Necessary To Observe in Their Installation and Operation, With a Few of Their Advantages

By DE WITT M. TAYLOR

IF NO air were present in a condenser, the vacuum would be limited only by the lowest available temperature in the condenser, and this, in turn, would depend on the temperature of the cooling water. This vacuum would correspond to the pressure of the water vapor alone, but with air present the actual pressure will equal this vapor pressure plus that which the air would exert if it were present alone.

Now, since air cannot be condensed at ordinary temperatures, the only thing to do is to pump it out. This becomes difficult at high vacuums owing to the large increase in volume. Assuming that the amount of air to be removed per hour remains constant, if the vacuum is increased from 26 in. to 28 in., the volume is more than doubled. If the vacuum increases from 28 in. to 29 in., the volume is more than doubled again.

In reciprocating-engine plants, where 26 in. vacuum is usually the maximum, a simple pump which handles

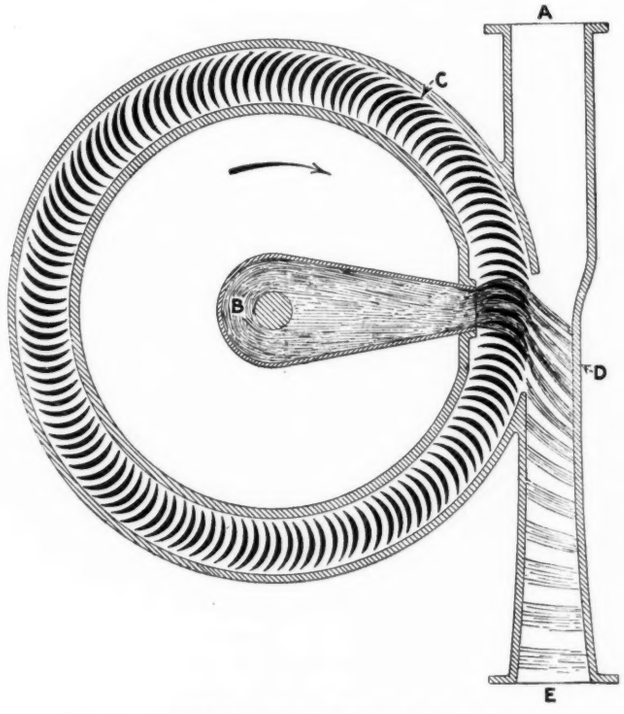


FIG. 1. DIAGRAM OF HURLING-WATER PUMP

both the condensate and the air gives satisfactory results. However, with the demand for higher vacuums for turbines some other means became necessary.

The commonest method was the use of a "wet" pump to take out the condensate and a so-called "dry-air" pump to take care of the air. The wet pump, or removal pump, may be a displacement pump or a centrifugal pump.

The first type of dry-air pump in general use was simply a reciprocating air compressor. The troubles of re-expansion of the air in the clearance, which increased even faster than the vacuum increased, led to many refinements and complicated valve gears. This, of course, meant high first cost and high maintenance cost,

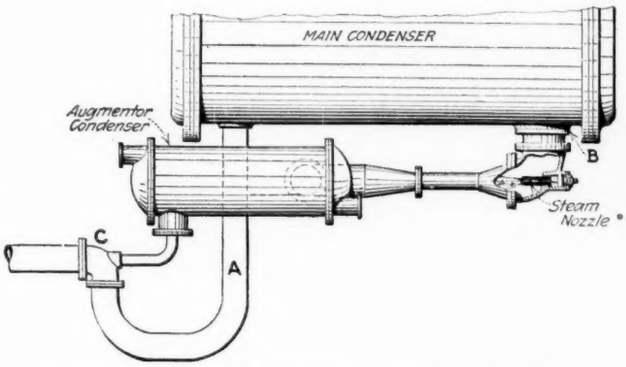


FIG. 2. DIAGRAM OF PARSONS' VACUUM AUGMENTOR

as well as losses due to interruption of service for repairs to the pump. It also meant the additional lubrication and cooling problems which are present in all reciprocating air compressors. A number of pumps of the rotary type were used with reasonable success, but these also were subject to the same or other disadvantages.

These difficulties led to the development of the hydrocentrifugal or "hurling-water," pumps. A number of these pumps, alike in principle but differing greatly in detail, were produced. Fig. 1 shows, diagrammatically, one example of this type. Air is admitted from the condenser at *A*, and the hurling water enters at the center of the pump to the chamber *B*. At *C* are shown the blades of a centrifugal pump rotor. As each blade passes the nozzle shown in the chamber *B*, it cuts off a "slug" of water and throws it out into the nozzle *D*. The air is trapped between these slugs and carried out through the discharge tube *E*. Other hurling-water pumps discharged the water all around the rotor into an annular space to which the air was admitted. Outside this annular space were a number of passages similar to the guide passages in a turbine pump. The water trapped the air and carried it out through these passages to the pump discharge.

The hurling-water pumps showed a marked improvement over the reciprocating compressor, both in simplicity and in capacity. The reciprocating pump shows a decreasing capacity as the vacuum increases, and finally reaches a point where the capacity becomes zero. Owing to the increased water velocity at high vacuums, the hurling-water pump increases its capacity as the

vacuum increases. On the other hand, the hurling-water pump uses two or three times as much power as the reciprocating pump and is slow in starting, by reason of its low capacity at low vacuums.

Charles A. Parsons was the first to use the steam ejector for condenser work, in connection with his "Vacuum Augmentor," which he installed in turbine-driven channel boats. In this case the steam jet simply increased the air pressure so that the combined water and air pump could handle it. A diagram of the arrangement is shown in Fig. 2. The condensate was drained from the bottom of the main condenser through pipe *A*, in which was a U-bend to form a water seal. Air was drawn out through the pipe *B*, by a steam ejector which discharged into a small *"Augmentor Condenser,"* about one-twentieth the size of the main condenser. This augmentor condenser condensed the steam from the ejector and delivered it, with the air, into the main condensate pipe at *C*, from which point the whole mass passed to the main air pump. In this apparatus the steam ejector increased the pressure of the air by only one or two inches, so that with a vacuum of 29 in. in the main condenser, the vacuum at point *C* would be about 27 or 28 in. The water seal in the pipe *A* prevented the air from working back into the main condenser.

Meanwhile, Maurice Leblanc, in France, had been experimenting with steam ejectors to produce high vacuums for refrigerating work. While the problems of refrigeration are different from those of condenser work, one important fact was established. It is difficult to produce and maintain high vacuums by one ejector alone. In most cases, therefore, two ejectors are used in series.

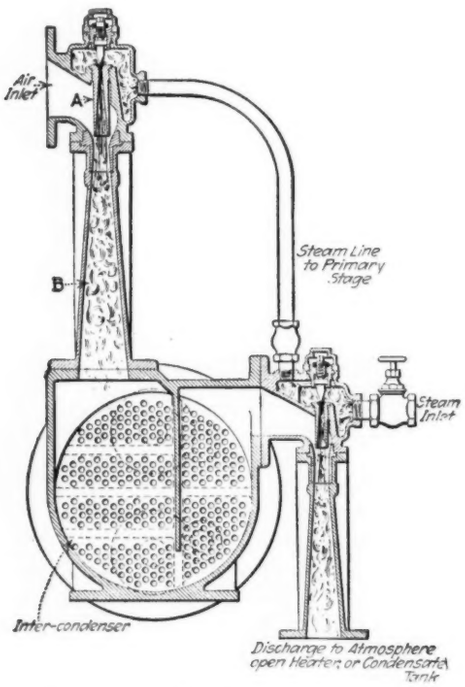


FIG. 3. WHEELER STEAM-JET AIR PUMP

Several years ago, the question of steam ejectors as condenser air pumps was seriously taken up by American manufacturers. Today there are several makes of such pumps on the market, and they seem likely to prove a decided factor in the business.

Fig. 3 shows the general design of the Wheeler Steam Jet Air Pump, as made by the Wheeler Condenser and Engineering Co., Carteret, N. J. Steam at 125 lb. pressure is admitted at the *steam inlet*, and part of it passes through the bent pipe to the primary, or first-stage, nozzle *A*. This nozzle is practically the same as a single-stage steam-turbine nozzle, so the steam leaves it with a very high velocity. As it leaves the nozzle, the steam picks up, or entrains, the air and carries it on through the discharge tube *B*, into the *intercondenser*. Here the steam from the primary nozzle is condensed and this condensate is drained, through a U-tube seal (not shown) into the bottom of the main condenser, from which it is pumped by the main condensate pump. The air in the intercondenser is drawn off by the secondary, or second-stage, nozzle, which is similar to the one just described.

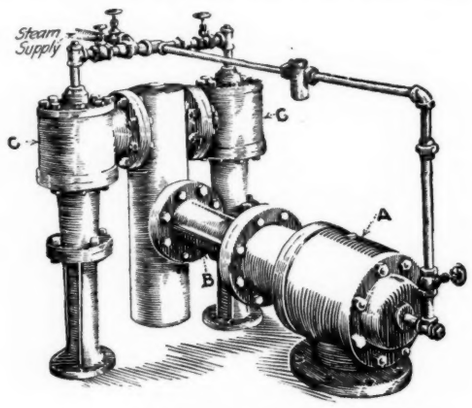


FIG. 4. CROLL-REYNOLDS EVACTOR

In this machine the condensate from the main condenser is used as cooling water in the intercondenser. This reclaims the heat in the exhaust steam from the first nozzle, and at the same time reduces the work in the second-stage nozzle, since it has only the air to handle. The tubes at the right of the partition, in the intercondenser, may be supplied with raw water when starting, or when the load is so light that there is not enough condensate from the main condenser.

At Fig. 4 is shown the general appearance of the Croll-Reynolds "Evactor," made by the Croll-Reynolds Co., New York City, and by the Ross Heater and Manufacturing Co., Buffalo, N. Y. The first-stage ejector is shown at *A* and the intercondenser or intercooler at *B*. This intercooler is of the jet condenser type, and the boiler-feed makeup water is generally used as cooling water. For the second stage, two ejectors, marked *C*, are used in parallel, thus giving greater flexibility as one or both may be used as needed.

The Alberger "Air Occluder," made by the Alberger Pump and Condenser Co., New York City, is shown at Fig. 5. Air enters at *A* to the first-stage ejector *B*. The second-stage pump is at *C* and the jet-condenser type intercooler at *D*. Both the Croll-Reynolds and Alberger machines may be equipped with surface type intercoolers if necessary.

Fig. 6 shows a section of the "Radojet" air pump made by the C. H. Wheeler Manufacturing Co., Philadelphia, Pa. This differs from the previous pumps in

the design of the secondary nozzle and in that it is usually built without an intercooler. Air and steam are admitted as shown and part of the steam passes up through the pipe at the left, to the chamber above the first-stage nozzle *A*. The steam and entrained air go down through the discharge tube *B*, to the second-stage suction chamber *C*. Steam for the second stage passes through the annular nozzle formed by the hollow cone *D* and the

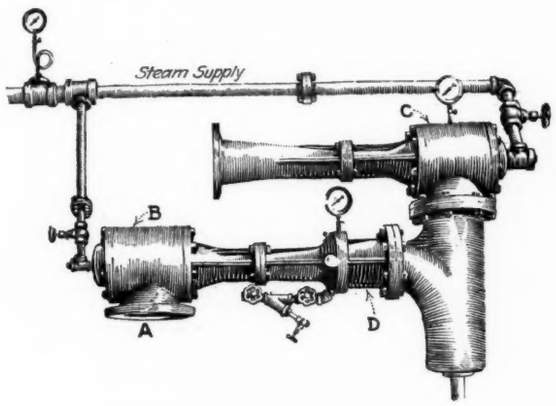


FIG. 5. ALBERGER AIR OCCLUDER

conical plate *E*. This gives a jet in the form of a thin circular sheet, offering a very large surface for entrainment. This secondary nozzle handles the air and also the steam from the primary nozzle and delivers them through the discharge diffuser *F* to the delivery space *G* and then to the discharge. The space *G* is similar to the discharge passage in a centrifugal pump.

The Elliott Co., of Pittsburgh, Pa., manufacturer of the Elliott-Ehrhart Ejector, has developed a single-stage outfit which it claims is more effective than the two-stage machine. Referring to Fig. 7, the curve *A* shows the variations in capacity of a typical two-stage ejector, while the line *B* is characteristic of a single-stage outfit. It will be noted that the two-stage machine will give a very high vacuum at zero capacity—that is, with the air suction blanked off—but that the vacuum drops off rapidly as the capacity increases. On the other hand, the single-stage ejector will not give so high a vacuum at zero capacity, but the vacuum does not drop off so rapidly, as more air is admitted. It is reasonable to assume that if a single-stage outfit could be so constructed as to give substantially the same vacuum at zero capacity as the two-stage outfit, the characteristic curve would have the same shape as *B* but displaced upward as at *C*. The Elliott Co.'s engineers claim to have succeeded in designing such an ejector, which gives about one-tenth inch less vacuum than the two-stage machine at zero capacity, but which maintains a much better vacuum as the amount of air handled increases. The curve *C* shows the characteristic of this Elliott-Ehrhart single-stage outfit. When very low steam consumption is desired, the Elliott Co. arranges an ejector in two stages, with an intercondenser.

One very important point in the design of two-stage steam-jet air pumps is the use of the proper ratio of compressions, or in other words the proper intermediate pressure. It must be remembered that these pumps are simply two-stage air compressors. Theoretically, the best intermediate pressure is given by the equation $P = \sqrt{P_1 \times P_2}$, where P is the intermediate pressure, P_1 is the initial pressure or, in this case, the condenser pressure, and P_2 is the final pressure. This equation applies to dry air in piston compressors with perfect intercooling, so it will not give accurate results for steam-jet pumps. However, it gives an approximate idea of what the intermediate pressure should be. As an example, assume a vacuum of 29 in. with a 30-in. barometer. Then $P_1 = 1$, $P_2 = 30$, and $P = \sqrt{1 \times 30}$ or 5.48 in., which corresponds to a vacuum of 24.52 in. Of course the exact best value for the intermediate pressure can be found only by actual tests on various pumps and under various conditions.

The conditions for each individual plant should settle the question of the use or non-use of an intercooler. Its use is mainly to cut down the work of the second-stage jet and thereby lower its steam consumption, and even

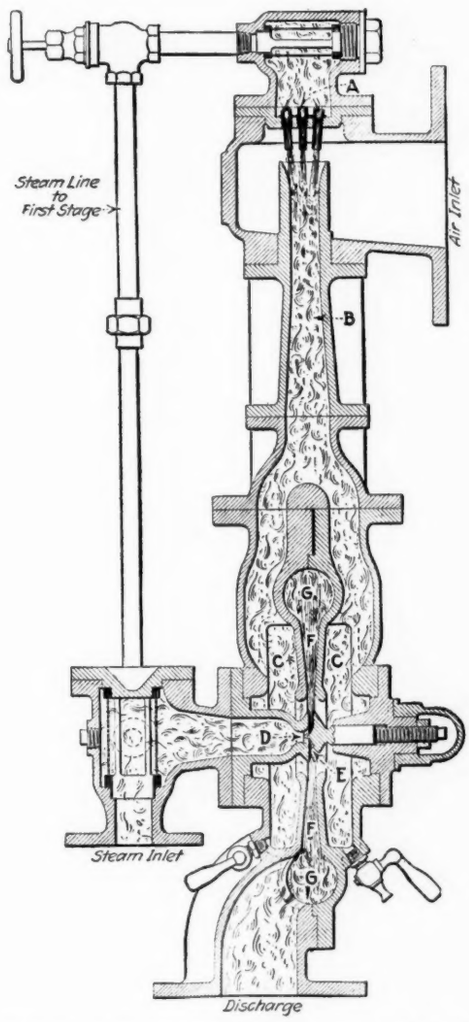


FIG. 6. C. H. WHEELER RADOJET AIR PUMP

those who advocate omitting it admit that it will lower the steam consumption by about 50 per cent. On the other hand, if the discharge from the pump is used to heat feed water, practically all the heat from the steam is reclaimed, so that the actual amount of steam used is not important. If there is plenty of exhaust steam from other sources for the needs of the plant, an intercooler would probably be desirable, but if exhaust steam

is scarce, it would seem to be an unnecessary complication. In any case the heat in the steam from the second-stage nozzles should be reclaimed. The curves of Fig. 8 show a comparison of the steam consumptions of a hydraulic or hurling-water pump (curve *A*) of a non-condensing ejector (curve *B*) and of a condensing ejector (curve *C*). The curve *A* for the hydraulic pump is based on a steam drive taking 35 lb. of steam

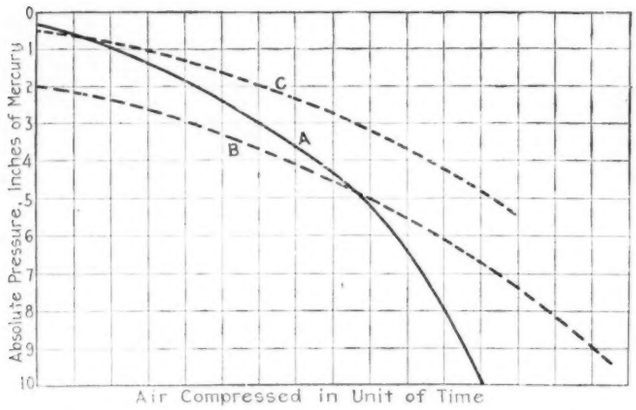


FIG. 7. VARIATIONS IN CAPACITY WITH VACUUM OF SINGLE- AND TWO-STAGE STEAM-JET AIR PUMPS

per horsepower per hour, which seems to be a fair average for this type of outfit.

Fig. 9 shows one way of reclaiming the waste heat. The discharge from the pump is led into the *condensing tank*, through which either the makeup feed water or the main condensate passes. Here all the steam from the jets is condensed and its heat taken up by the water. At the same time the air escapes from the surface of the water and out through the vent. If the supply of water to the condensing tank is stopped, owing to shutting down the main engine, the water in the tank would soon become too hot to condense the steam. To prevent this, a pipe is sometimes run from the tank to the main condenser. In this pipe is a valve which is controlled by a thermostat placed in the condensing tank. When the water reaches the temperature for which the thermostat is set, the valve is opened and water is drawn from the tank into the main condenser, where it is cooled, and it is then returned to the tank by the main condensate pump. This device has been found especially useful in marine work in connection with maneuvering and during stand-by periods.

Apparatus using steam nozzles requires a constant steam pressure for efficient operation. The variations in boiler pressure found in the average plant are too great for the proper operation of steam-jet air pumps. Therefore a reducing valve or regulator to maintain a constant pressure must be placed in the steam supply line and the boiler pressure must be at least twenty-five pounds higher than that for which the pump is designed. It is very important, also, that the discharge pressure should be kept constant and very little if any above atmospheric pressure. The dam shown in the condensing tank in Fig. 9 keeps a constant head of water on the discharge pipe and should be adjusted so that this head is no more than enough to keep the steam from blowing out. The check valve shown in the discharge pipe is necessary to prevent water being drawn into the condenser if the air pump is shut down before breaking the vacuum.

The amount of air brought into the condenser with the feed water, as well as that in the injection water when jet condensers are used, can be estimated in advance with reasonable accuracy. The amount which leaks in, however, is very uncertain and varies from time to time as the conditions of packing, etc., change. Therefore, enough air-pump capacity must be provided to take care of the worst conditions. The amount of steam used by a jet pump depends on the pressure and on the size of the nozzles, and is independent of the amount of air handled. On this account it is usual to install two or more pumps instead of a single large one. This allows the operating engineer to meet changes in load and still run pumps at maximum economy. In starting, all the pumps may be used to exhaust the air from the condenser quickly and then only enough run to handle the load. If an extra pump for use as a spare is desired, the cost is not prohibitive, although the chances of trouble are so small that a spare is seldom thought necessary.

The work of operating steam-jet pumps consists simply of starting and stopping. Before starting, the usual precaution of draining all cold apparatus before admitting steam is, of course, necessary. The steam valve to the first-stage nozzle should be closed and then the main steam valve opened a little. After the machine is warmed up, close the drips and open the main steam valve wide, making sure that the pressure regulator maintains the proper pressure in the line. When the vacuum gage shows about 25 in., open the valve to the first-stage nozzle. In stopping, first close the valve in the air line between the condenser and the pump and

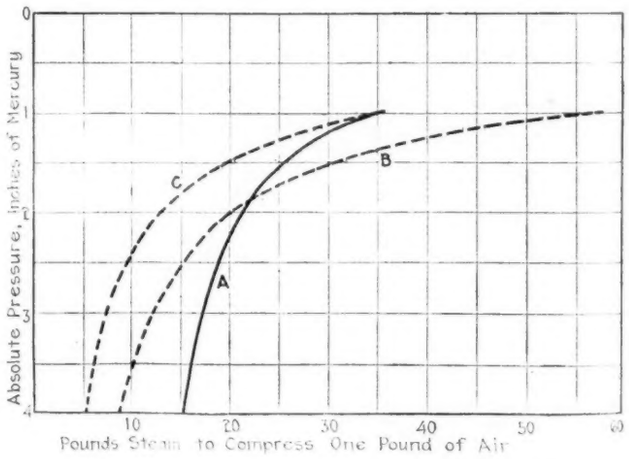


FIG. 8. COMPARISON OF STEAM CONSUMPTIONS OF HYDRAULIC PUMPS AND STEAM-JET EJECTORS

then close the main steam valve and open the drips. When several steam-jet pumps are installed, run only enough to carry the load, but see that these are run with the valves wide open and that steam is supplied at the designated pressure so that the nozzles may work under their designed conditions.

Some interesting data regarding air ejectors were given in a paper by G. L. E. Kothny, read before the Society of Naval Architects and Marine Engineers in New York, Nov. 14, 1919. A curve was shown, giving

the capacities of a certain machine at different vacuums and also the capacities using only the second-stage nozzle. The maximum vacuum obtained with the complete machine was about 29.75 in. of mercury and with the second-stage nozzle alone about 27.5 in. Both these figures were obtained with the air inlet blanked off so as to give zero capacity, and are referred to a 30-in. barometer.

As the vacuum was decreased, the capacities increased, but with vacuums below 25.5 in. the capacity of the second-stage nozzle alone was greater than that of the

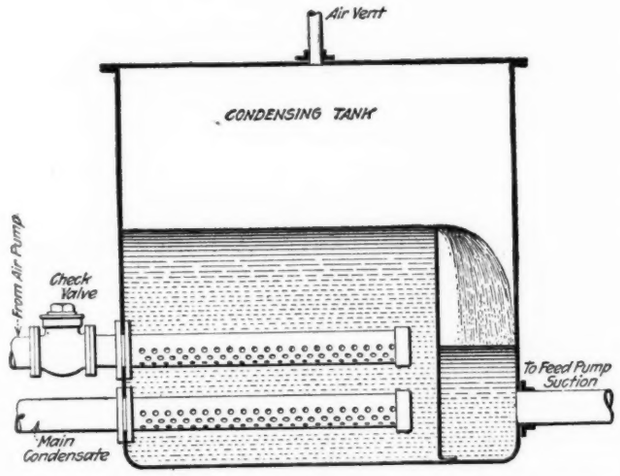


FIG. 9. ARRANGEMENT FOR RECLAIMING HEAT IN DISCHARGE FROM STEAM-JET AIR PUMPS

entire machine. This explains the desirability of using only the second-stage nozzle in starting. These figures check closely with those shown on the curves at Fig. 7, which were obtained from an entirely different source and from tests on a different machine.

Other curves showed the effect of a back pressure (on the discharge) on the vacuum. These indicated that for back pressures below a given amount the vacuum was practically constant, but above this "critical" back pressure the vacuum dropped very rapidly. The value of the back-pressure limit depends on the steam pressure used and was about 2.5 in. of mercury for 100 lb. gage, 5.0 in. for 110 lb. gage and 8.5 in. for 120 lb. gage. It must be remembered that all the values given in Mr. Kothny's curves are from tests on a certain individual pump and would not be true for every pump. However, they are of value as giving a rough guide as to how such pumps would operate.

Another paper read before the American Society of Mechanical Engineers at the annual meeting in New York, Dec. 2-5, 1919, by Frank R. Wheeler, described the various methods of removing air and covered some of the ground that had already been covered in preparation of the present article.

Steam-jet air pumps are small in size and require no foundations; therefore they are low in cost and easy to install. They have good capacity, even at high vacuums. By using several small pumps, which is too expensive with other types, great flexibility can be obtained. While their steam consumption is high, most of the heat can be reclaimed, so that they are economical in fuel consumption and they require little or no attention during operation.

Supersaturated Steam

Supersaturated steam has been for a number of years only a thing of interest to scientists, but with the modern development of the steam turbine it is attracting more or less attention among engineers. It has been claimed that its presence offers an explanation of some of the otherwise unexplainable performances of steam in turbines and in turbine nozzles.

Supersaturated or supercooled steam may be defined as steam which exists as a vapor at temperatures below that at which it should condense under the existing pressure. It is possible, under laboratory conditions, to cool pure water below 32 deg. F. without the formation of ice. This condition is very unstable, however, and the slightest disturbance will result in the immediate freezing of some of the liquid. The formation of ice of course results in the liberation of heat, which will raise the temperature of the mixture. The water will not freeze above 32 F., so the process will stop when enough heat is liberated to raise the temperature to that point and equilibrium is said to be established.

In a similar way superheated or dry saturated steam may, under certain conditions, be cooled below the condensing temperature and still remain a vapor. As in the case of undercooled water, this supersaturated or "undercooled" steam, is in an unstable condition and takes the first opportunity to partly condense and reestablish its equilibrium. As soon as condensation begins, heat is liberated, which tends to raise the temperature of the mixture, and this will go on until the state of equilibrium is reached. In other words, condensation will continue until enough steam has condensed to supply the heat necessary to raise the temperature of the whole mass to the saturation temperature corresponding to the pressure.

Behavior of Steam in an Orifice or a Nozzle

When steam expands in an orifice or a nozzle, as it does in steam turbines, some of its heat is given up to increase the velocity of the steam itself. If the steam was originally dry and saturated, the loss of this heat will result in condensation. From the known properties of steam it is possible to calculate the quality, specific volume and velocity of the steam leaving the nozzle and hence to compute the weight flowing in a given time. It is obvious that friction will decrease this amount so that the theoretical value will be too high. Experiments by a number of investigators, however, have shown, under certain conditions, a *greater* discharge than is indicated by the theoretical formula. To explain this condition, it has been suggested that the steam in a turbine is not in a state of equilibrium and that it is supersaturated throughout its passage through the machine. In support of this theory several ideas have been brought forward by various engineers.

It is pointed out that a thermometer in the exhaust pipe of a turbine will indicate a lower temperature than that corresponding to the observed pressure, although the impact of the particles of steam against the thermometer bulb would tend to raise the temperature reading. This, however, might easily be explained by the difficulty of accurately measuring the pressure of the steam at high velocities and by the fact that any air in the steam would reduce the vapor pressure below the observed pressure even if the latter could be accurately measured.

Another argument brought forward is that a certain time is required for condensation. This is undoubtedly true, but the experiments of Dr. Stodola on steam discharging into the open air indicated that droplets were formed in probably about one ten-thousandth of a second. The conclusion has been drawn, however, from the experiments of C. T. R. Wilson, that a certain amount of undercooling exists at least over a period of time of the general magnitude of $\frac{1}{100}$ sec. If this latter time is correct, the possibility of supersaturation existing until the steam has passed entirely through a modern turbine is established in so far as the time element is concerned.

The experiments of Mr. Wilson, which are described by him in the "Transactions of the Philosophical Society of London," Vol. 189, were undertaken to investigate condensation laws under sudden expansion of saturated dust-free air. As a result of his observations he concludes that sudden expansion to a certain point below the saturation point is accompanied by supersaturation, but that below this point the amount of condensation increases very rapidly. Mr. Wilson's results have received extensive recognition, especially in England. It has been pointed out, however, that, although starting with saturated air, his process of removing all the dust particles would result in condensing some of the moisture, so that his actual experiments were probably conducted with non-saturated or superheated vapor.

Considerable discussion has been brought out by an article entitled "A New Theory of the Steam Turbine," by H. M. Martin, in *Engineering*, London, Vol. 106. Mr. Martin claims not only that the steam in a turbine is not in thermal equilibrium above the so-called Wilson point, but that thermal equilibrium is never attained during the entire passage through the machine. In other words, the steam, after being cooled to the saturation point, is always supersaturated or undercooled even though some condensation may have taken place

Wet Steam Really a Mixture

One of the difficulties of understanding the situation lies in the conception most engineers have of what is really meant by "wet steam." If a pound of water is at the boiling point, any addition of heat will result in the formation of some steam. As more heat is added, more of the water is converted into steam and we call the whole mixture wet steam. If three-quarters of the pound is vaporized, the quality of the mixture is said to be 0.75, and most men think of it as a uniform mass having certain properties. As a matter of fact, there is 0.75 lb. of *dry* steam and 0.25 lb. of water present, and this is true even although the water is in the form of fine drops thoroughly mixed with the steam. Now, water and steam have different properties, and while the properties of a mixture of the two can very conveniently be computed by the ordinary conception of a homogeneous substance, this is true only when conditions allow the whole mass to be in stable equilibrium.

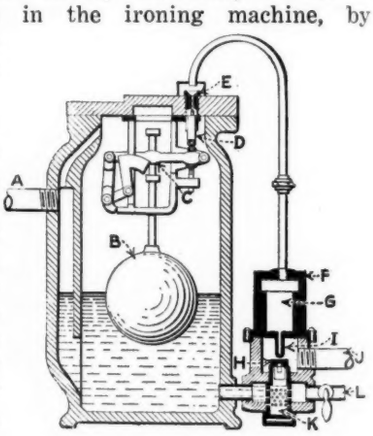
A study of the well-known temperature-entropy diagram shows that the expansion of dry saturated steam in a nozzle results in some condensation. On the other hand, if water at the boiling point for the existing pressure is allowed to expand in a nozzle, some of it is vaporized. Starting, then, with dry saturated steam, the moment any condensation takes place we have a mixture of water and steam. As the expansion proceeds, some of the water is re-evaporated and some more of the vapor is condensed. Remembering that a certain period of time is necessary for both condensation and evaporation to take place, it seems probable that both supersaturated steam and superheated water may exist together. This condition is furthered by the rapid movement of the mixture, which prevents complete interchange of heat between the various particles. This disturbance of the mass also makes the accurate measurement of pressures, temperatures, etc., difficult if not impossible.

It must be remembered that the conditions described are very unstable and that they will exist only until a condition of equilibrium can be re-established. While this unstable condition exists, however, the properties and proportions of the liquid and vapor are dependent on the local conditions, which in themselves are constantly and rapidly changing. From this viewpoint any attempt to make logical formulas for the behavior of steam in a turbine promises to lead to excessive complication. It would seem reasonable, then, that the present method of deducing formulas for the behavior of the steam on the assumption that it remains in thermal equilibrium and then modifying or correcting these formulas by factors determined by actual test still offers the most practical method of solving the problems of steam-turbine design.

In other words, the steam in a turbine is not in thermal equilibrium. It is probable that supersaturated steam is present a part if not all of the time. The number of uncertain and variable factors, however, make the deduction of logical formulas impractical.

The Miller Steam Trap

This trap, known as the Miller, was designed primarily for use with laundry machinery so that a constant temperature in the ironing machine, by thoroughly draining it of condensation, could be maintained.



SECTION THROUGH TRAP

In the illustration the details of design of the trap, which is manufactured by the C. J. Miller Co., 1225 Columbia Avenue, Philadelphia, Pa., are shown. Condensation enters through the inlet *A*. The float *B* holds the lever *C* down, thus pulling the pilot valve *D* from the seat *E*. Steam and air then flow through the pilot valve disc *H*, and close the discharge valve.

As the water rises in the trap, it pushes the float *B* upward until the pilot valve *D* is closed, which action cuts off steam from the cylinder *F*. An air vent *I* releases the pressure in the trap, and the discharge valve *H* is forced wide open to the discharge pipe *J*.

Below the discharge valve *H* there is a strainer *K* to protect the valve from sediment, and the blowout cock *L* permits of blowing out such sediment as collects on the outside of the strainer. Removing the seat holder from the bottom of the valve permits the seat and valve to be removed easily for regrinding or renewal.

Burning Illinois Coal from Vein No. 5

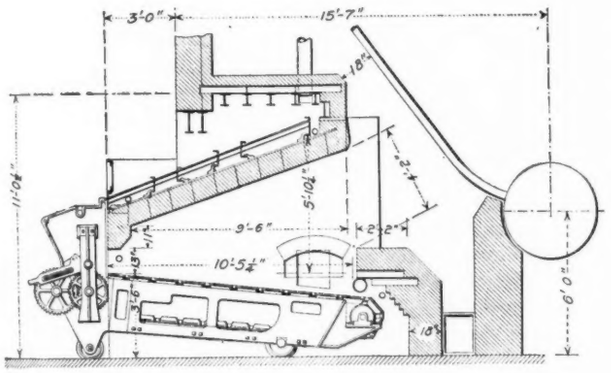
By T. A. Marsh

Coal from the fifth vein of Illinois is produced in the Harrisburg and Springfield districts. That produced in the Harrisburg district or Saline County, is by far the better coal. A comparison of screenings from the two districts by analysis is as follows:

	Moisture	Volatile	Fixed Carbon	Ash	Sulphur	B.t.u. Com.	B.t.u., Dry Basis	Fusion Temp. of Ash
Springfield No. 5..	12.2	33.2	35.00	19.6	4.0	10,353	11,900	2,179
Harrisburg No. 5.	6.75	33.49	46.72	13.04	3.0	11,493	12,325	2,291

Of all the coal produced in Illinois that from the No. 5 seam in Saline and Gallatin Counties is among the highest in heat values on a "unit coal" basis that is moisture and ash free.

The Harrisburg, or Saline County No. 5, has a high heat value and relatively high fusion point for ash,



FURNACE IN WHICH THE TESTS WERE MADE

making it a desirable fuel in plants having limited boiler capacity. Some recent tests with this fuel may be of interest. The boiler on which the tests were conducted is of the Stirling type, having 15 tubes per section and 20 tubes in width, with a total steam-making surface of 5,020 sq.ft. The furnace, which is 10 ft. wide, is equipped with a chain grate 9 ft. 6 in. wide by 11 ft. long, giving an active area of 101.3 sq.ft. and a ratio to steam-making surface of 1 to 49.5.

The accompanying drawing shows the design of the furnace. It will be noticed that the boiler is set 6 ft. from the center line of the mud drum to the floor line and that there is a furnace projection of 3 ft. forward of the boiler front. These proportions and the general arrangement were determined in the design with the idea of smokelessness as the leading feature. The entire grate surface has a furnace roof over it.

This is a very desirable feature where smokelessness is to be assured.

From the test results given in the table it will be seen that while the furnace was designed primarily for smokelessness, high efficiencies and excellent capacities were obtained. Some of these tests were made with coal that had been on fire in storage, rendering it more difficult to produce results than with coal that is freshly mined.

Daily performance of the plant is a repetition of these results. Capacities of 200 per cent and above are frequently reached and maintained, while the maintenance and labor of operation are unusually low. Relative to the item of main interest when the plant was designed—smokelessness—the chimney never emits more than the lightest blue haze, even when all boilers are being carried at high ratings.

Old Engine Dismantled, Installed 69 Years Ago

An interesting old engine owned by the Taunton-New Bedford Copper Co., of Taunton, Mass., has at last been dismantled. George A. Corliss offered to let the company have this engine if he could have the amount saved in coal for one year, but the management at that time was advised not to accept this offer. They later bought the engine, paying him much less than he would have made if they had taken it when he offered it on the original terms.

The engine was a walking-beam type 33 x 72-in. Corliss & Nightingale, installed in 1851 for the purpose of running three stands of rolls for rolling sheet brass and copper. It was originally connected to the roll train by a train of gears, but was taken down and moved ahead about twenty-five years ago at which time it was geared directly to the rolls.

A peculiar feature of the installation was the location of the flywheel, which was placed on the end of the crankshaft instead of between the bearings as is the usual method. The bearing nearest the flywheel is about four times the length of the regular bearings. The governor was driven by 1¼-in. diameter braided cotton rope. The speed of the engine was 30 r.p.m. The steam pressure was 35 to 40 lb., being maintained by an 8-in. Mason reducing valve which was installed about 25 years ago, after the old low-pressure boilers were condemned and dismantled for a more modern high-pressure installation. At present there are four Corliss engines ranging from 135 to 750 hp., also a reversing blooming-mill engine of 1,000 hp., together with boiler room and the usual auxiliaries.

RESULTS OF TESTS ON 520-HP. BOILER EQUIPPED WITH CHAIN GRATE STOKER

	Coal Analysis as Fired					Draft, Inches of Water								
Name of Coal	Moisture	Volatile	Fixed Carbon	Ash	B.t.u.	Over Fire	Before Damper	Lb. of Dry Coal per Sq.Ft. of Grate Per Hour	Per Cent CO_2 Before Damper	Flue Gas Temp.	Equiv. Evap. per Lb. Dry Coal Fired	Boiler Hp. Developed	Per Cent Rating Developed	Combined Efficiency
Harrisburg, Ill., No. 5	12.73	.....	.....	17.35	10,407	0.31	0.64	33.58	12.44	609	8.84	875	175	71.6
Harrisburg, Ill., No. 5	9.95	.....	.....	16.12	10,955	0.18	0.33	25.58	13.12	548	9.63	720	144	76.8
Eldorado screenings	12.1	31.25	41.08	15.57	10,469	0.26	0.58	32.65	12.05	612	9.34	896	179	76.1
Harrisburg, Ill., No. 5	12.98	30.73	40.38	15.91	10,347	0.28	0.96	32.0	11.65	623	9.56	899	180	78.1
Harrisburg, Ill., No. 5	13.36	.....	.....	15.26	10,683	0.25	0.42	30.0	13.08	577	9.21	814	163	72.6
Harrisburg, Ill., No. 5	9.50	30.01	50.94	11.35	12,000	0.34	0.73	31.4	12.20	548	10.23	826	164	74.8

How Three-Phase Transformers Operate

By J. B. GIBBS
Engineer, Transformer Department, Westinghouse Electric and Manufacturing Company

Comparison is made between single-phase transformers grouped for operation on a three-phase circuit and a three-phase transformer. It is shown that the three-phase transformer is practically three single-phase transformers combined into one. What may be done to operate a three-phase transformer when one phase become damaged, is explained.

IN BUILDING transformers for three-phase circuits, the three windings can be combined on a single iron core. This makes it possible to take advantage of the phase difference in the three circuits so as to save a part of the material. Fig. 1 represents three single-phase core-type transformers of the same size. The full lines indicate the cores and the dotted lines the space occupied by the coils. Now suppose that the three cores are pushed together so that they touch, as in Fig. 2, and that the shaded portion of the iron is cut away. Also take the unshaded strip at the right of *C* and transfer it to the left of *A*, as shown by the dotted lines in Fig. 2. This gives the iron circuit shown in Fig. 3, which has the same cross-section of iron as each circuit in Fig. 1, and has also an increased space for coils besides saving the part of the iron shown shaded, Fig. 2. This is not all clear gain, however, for the total cross-section of the copper in the coils for Fig. 3 must be the same as for Fig. 1, while the mean turn will be greater because the coils will be thicker. In practice a part of the saving is taken out in the iron circuit and a part in the copper circuit, and the net result is that the active material in a three-phase transformer costs about 10 per cent less than the active material in three equivalent single-phase transformers. The active material may be something like one-half of the total cost of the transformer, so the actual difference in cost between a three-phase transformer and a bank of three single-phase transformers may depend as much on the mechanical as on the electrical design.

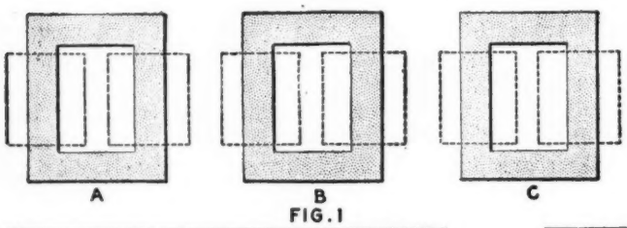


FIG. 1

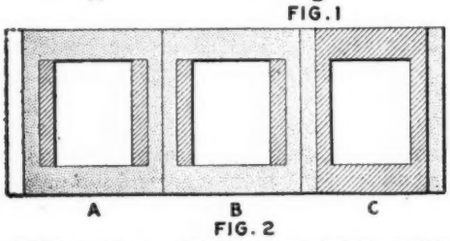


FIG. 2

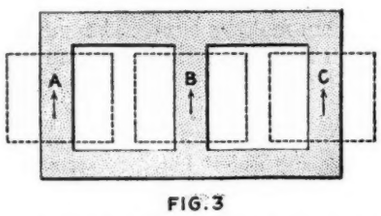


FIG. 3

FIGS. 1 TO 3. COMBINING THREE SINGLE-PHASE CORE-TYPE TRANSFORMERS INTO A THREE-PHASE UNIT

A vector diagram of the fluxes in the three legs of a three-phase core-type transformer is given in Fig. 4, which shows that the resultant of the flux in any two legs, as indicated by the dotted lines, is just equal and opposite to that in the third leg. This means that at any instant the sum of the "up" flux in any two legs is just equal to the "down" flux in the third leg. In a similar way three single-phase shell-type transformers can be combined to form a three-phase shell-type unit. Figs. 5, 6 and 7 correspond respectively to Figs. 1, 2 and 3. Fig. 5 shows the magnetic circuit of the three single-phase shell-type transformers; Fig. 6, by the shaded part, indicates the iron which can be saved by the combination; Fig. 7 represents a three-phase shell-type transformer's core. In this case the single-phase coils might be used without change, and the total saving would be represented by the shaded part of the iron, Fig. 6. The magnetic flux in the parts of the core marked *D* and *E* will evidently be one-half of the flux in the cores *A* and *C* respectively. Consider how much flux there will be in the other parts of the iron. Since the coils are connected in a three-phase circuit, the fluxes in the three cores must be 120 deg. apart, as shown by *A*, *B* and *C*, Fig. 8. Suppose, first, that the coils are connected symmetrically in the three circuits. Then the flux in *F* will be the vector sum of one-half the flux in *A*, minus one-half the flux in *B*. The construction for this is shown in Fig. 8 by the dotted lines, and the resultant is a flux in *F* which is 0.866 of the flux in *A* or *B*. Similarly, the flux in *G* will be the vector sum of one-half the flux in *B* minus one-half the flux in *C*, or 0.866 of the flux in *B* or *C*. This would necessitate having the iron in the parts *F* and *G* 0.866 as wide as the iron in the cores *A*, *B* and *C*, and would result in very little saving of the material. Now suppose that we reverse the connections of the coils on the core *B*, so that the direction of the flux is reversed with respect to the flux in *A* and *C*. The flux in *F* will now be the vector sum of one-half the flux in *A* plus one-half the flux in *B*. The construction for this is shown in Fig. 9, and the resultant is found to be equal to one-half the flux in *A* or *B*. Likewise the flux in *G* is one-half the flux in *B* or *C*. In a shell-type three-phase transformer, therefore, the windings on the middle leg are always reversed, and the parts *D*, *E*, *F* and *G* of the iron circuit are all made one-half as wide as the cores *A*, *B* and *C*.

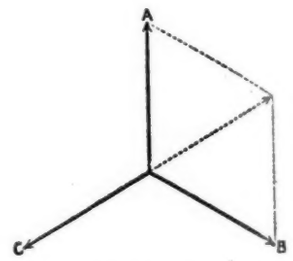


FIG. 4. VECTOR DIAGRAM OF FLUX IN THREE-PHASE TRANSFORMER

The choice between a three-phase transformer and a bank of single-phase transformers depends largely on the judgment of the engineer who is purchasing them, but in general, three-phase transformers are more popular than they were several years ago. This is due partly to improvements in design and insulation, but principally to the better acquaintance of operating men with the three-phase type. The chief arguments for and against three-phase transformers as compared with banks of single-phase transformers may be summarized thus:

For: (1) Occupies less total floor space; (2) weighs less; (3) costs less; (4) only one unit to handle and connect.

Against: (1) Greater weight per unit; (2) the average line man is more familiar with single-phase transformers; (3) in three-phase core-type transformers trouble in one phase may be communicated to other phases. This is a possibility rather than a probability.

The last objection does not carry much weight, for in shell-type three-phase transformers the separation of the windings is almost as effective as in three single-phase transformers, while even in the core type heavy insulating barriers are always put between the windings on different legs, so that breakdowns from this cause are very rare.

It is the usual practice to make the connections between phases in a three-phase transformer at a terminal board below the oil level inside the case. This makes it possible to bring only three high-voltage and three low-voltage leads out of the case and greatly simplifies connection to the line.

There are four principal ways of connecting the windings of three-phase transformers—delta-delta, star-delta, delta-star, and star-star. These are exactly the same as the corresponding connections between three single-phase transformers in a three-phase bank, and the star-star connection is generally avoided for the same season that it is avoided in single-phase transformers; although if the three-phase transformer is of the core type, the shifting of the neutral is less extreme than in a bank of single-phase transformers.

In case of trouble in one phase of a three-phase transformer, the other two phases may be operated in open-delta connection to carry 58 per cent of the rating, if the transformer connection is delta-delta. This is the same statement that can be made concerning a bank of single-phase transformers. To make this change in a three-phase transformer, it is necessary to disconnect both high- and low-voltage windings of the damaged phase, at the terminal boards. If the transformer is of the core type, both windings of the damaged phase must be open-circuited. If the transformer is of the shell type, the damaged windings may be open-circuited or short-circuited. The reason for this will be evident from a consideration of the shape of the magnetic circuits. Figs. 10 and 11 are repetitions of Figs. 3 and 7 respectively. Suppose that the winding *B* is damaged in both transformers, if phases *A* and *C* are to run in open-delta it is necessary that the fluxes in these two cores be 120 deg. apart and that the resultant flux have a return path. In the core-type, Fig. 10, transformer this return path is provided by the third leg *B*. But if there is a winding on core *B*, the flux passing through it will induce a voltage, and if there is a closed circuit a current will flow. This will increase to the point where the coil *B* will be burned out. In the shell-type transformer the core *B* does not provide the only path for the resultant flux, and if the coil is short-circuited it will merely cause the flux to take the other path.

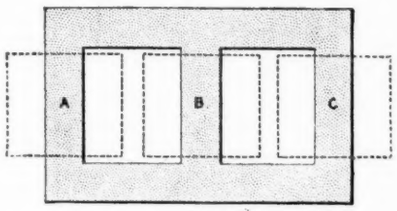


FIG. 10

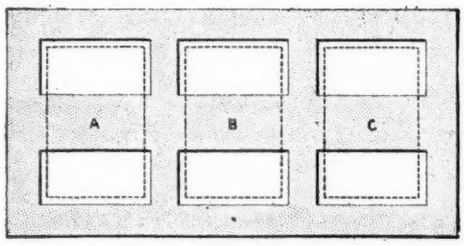


FIG. 11

FIGS. 10 AND 11. CORE-TYPE AND A SHELL-TYPE TRANSFORMER

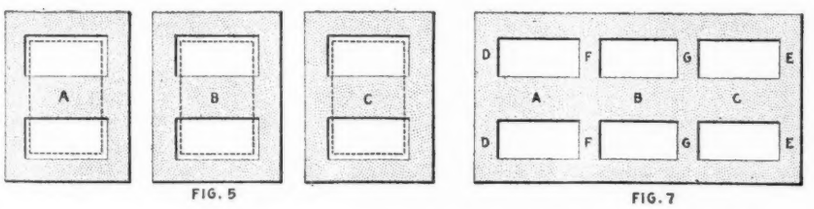


FIG. 5

FIG. 7

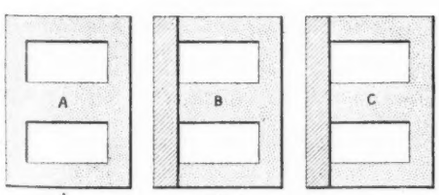


FIG. 6

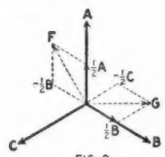


FIG. 8

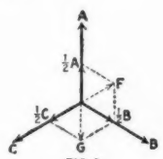


FIG. 9

FIGS. 5 TO 9. COMBINING THREE SINGLE-PHASE SHELL-TYPE TRANSFORMERS INTO A THREE-PHASE UNIT, VECTOR DIAGRAMS OF THE FLUXES

Recommendation that steps be taken to relieve the present car shortage in order that coal may be obtained in sufficient quantities to build up a reserve for New England and other Eastern industries for next winter has been made by the National Association of Cotton Manufacturers, according to *Coal Review*. Co-operation of chambers of commerce in securing assignment of a reasonable number of coal cars to the Eastern territory has been asked.

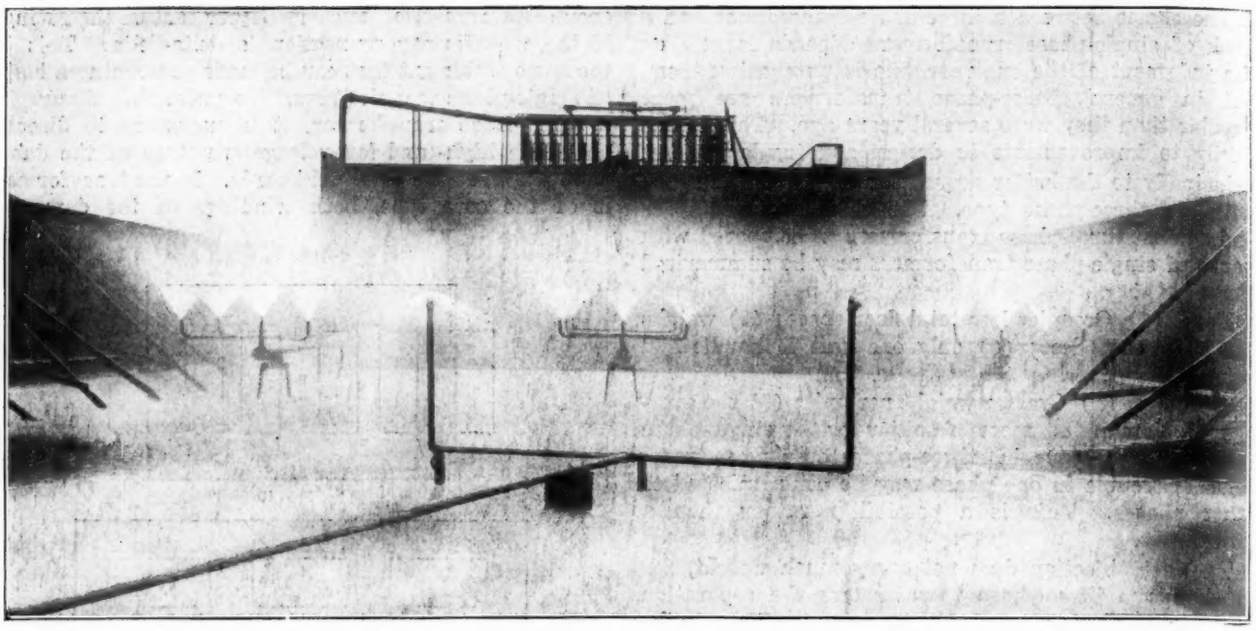


FIG. 1. A REFRIGERATION-PLANT SPRAY COOLING POND; CONDENSERS ON ROOF IN THE BACKGROUND

Refrigeration Study Course—XII. Cooling Water

BY H. J. MACINTIRE

REFRIGERATION and cooling water are similar terms, for without cooling water there could not be refrigeration. One would be as likely to try to operate a steam engine or turbine condensing without condensing water, or the oil engine without cooling water, as the refrigerating machine without the necessary amount of water at the temperature of the air or colder. As a matter of fact the first question that arises is, "What is the temperature of the cooling water?" and the second, "What is its cost?" In other words, it is desired to find out how fully we may use the water and what is its initial temperature.

Occasion has been taken before this to bring out the function of the cooling water in the refrigerating cycle. The compressor is a pump—a temperature pump in a way, as it raises the temperature level of the refrigerant to a point sufficiently high so that the cooling water at hand can condense the ammonia gas satisfactorily. In the ammonia condenser, as in any form of condenser, the cooling water removes the heat of liquefaction (latent heat) and in addition the superheat and some of the heat of the liquid. In consequence of this the water is warmed a certain amount, depending on the relative amounts of water used. In general it may be said that the heat removed is as follows:

The compressed ammonia gas, being superheated, has its superheat removed first and then the latent heat of liquefaction. Finally, the liquid ammonia is precooled slightly below the temperature of saturation. The cooling water has to remove all this heat, and it passes away from the condensers carrying this amount of heat away with it and is at a higher temperature in proportion. An example will show the conditions which prevail:

A compressor operating between 15.2 lb. and 175 lb. gage, has a temperature of discharge of 234 deg. F. and the temperature at the liquid expansion is 80 deg. F. The temperature of the water leaving the condenser is 90 and the entering water is 75 deg. F. Under these conditions there would be 92 B.t.u. of superheat to be removed from each pound of ammonia, and 490.8 B.t.u. of cooling to condense it at 175 lb. gage pressure and a temperature of 93.5 deg. F. Finally, to cool the liquid to 80 deg. F. requires 15.9 B.t.u., or a total of 598.7 B.t.u. per pound of ammonia. The useful available refrigeration from this same pound of ammonia is 484.9 B.t.u. and the difference, 598.7 — 484.9 = 113.8 B.t.u., is the work done by the compressor, resulting in heating the ammonia. This value may be shown in another way.

Taking a case where one pound of ammonia is compressed per minute, the net refrigerating effect is 484.9 B.t.u. or at the rate of 2.42 tons of refrigeration. With these conditions of operation it will require 1½ hp. per ton of refrigeration, or $1\frac{1}{2} \times 2.42 \times 42.4$ (the heat equivalent of a horsepower per minute) = 154 B.t.u. per min. The difference between 154 B.t.u. and 113.8 B.t.u. is accounted for by the mechanical efficiency of the compressor, and the heat removed by the jacket water (this latter being about 18 B.t.u.). It is clear from the preceding that the condenser and jacket water remove practically all the heat equivalent of the power supplied to the compressor by the engine or motor. In all likelihood about 1½ gal. per min. of cooling water will be used for every ton of refrigeration, and a 50-ton plant would require 75 gal. per min. If water is expensive to pump or has to be purchased, a method of cooling would be necessary to make it serve a second or a number of times over the condenser. The methods used are as follows:

In general there are three ways of cooling water where re-use of cooling water is required—cooling ponds, spray ponds and cooling towers. Each of these methods has its advantages in special cases.

The cooling pond can be used in locations where a natural body of water is available adjoining the plant. The water is cooled by being allowed to be brought in

surface contact with the air, and the evaporation (and cooling of the water) depends on the relative temperature of the air and on the humidity. The tendency would be for the pond to assume the temperature of the air, both due to giving up heat to the air and also due to the difference of the *saturation pressure* of the water and saturation pressure of the water vapor in the air. Roughly, the amount of cooling in *still air* for usual conditions may be taken at from 60 to 80 B.t.u. per sq.ft. of surface per hour, or about 225 sq.ft. of refrigeration. As the surface is the main consideration, it is not important to have any depth unless the refrigerating load is a variable amount, as, say, in the case of the chill rooms in a packing plant or the pasteurizing of milk and cream. In these latter cases it would be possible to use a smaller pond, but of some depth in order to store up enough cooling water. Usually, a foot or two is plenty.

Spray Ponds

Spray ponds differ from cooling ponds in the attempt to accelerate the rate of cooling. By forming a spray and finely dividing the particles of water, the air may quickly reach all the water immediately instead of waiting until each particle reaches the surface, as in the case of the cooling pond.

With the spray nozzle, Fig. 2, the water is pumped under 5 or 10 lb. pressure through a special nozzle designed to create a whirling spray of fine water particles. In most cases a cooling of 20 to 30 deg. F. may be obtained with a single spraying, and the final temperature depends on the fineness of the spray and the humidity. For instance, if the air has a humidity of 70 per cent and a temperature of 70 deg. F., the pressure of the water vapor in the air is 0.70 times 0.36, or 0.25 lb. per sq.in. It is usually assumed that the cooling water may be reduced to a temperature corresponding to a pressure about 0.15 lb. per sq.in. greater than that of the water vapor in the air, or (in this case) 0.25 + 0.15 = 0.40 lb., which corresponds to 73 deg. F. Some five or six per cent of the water is evaporated in the process.

A good rule is to allow one square foot of surface for every 250 to 300 lb. of water sprayed per hour, which

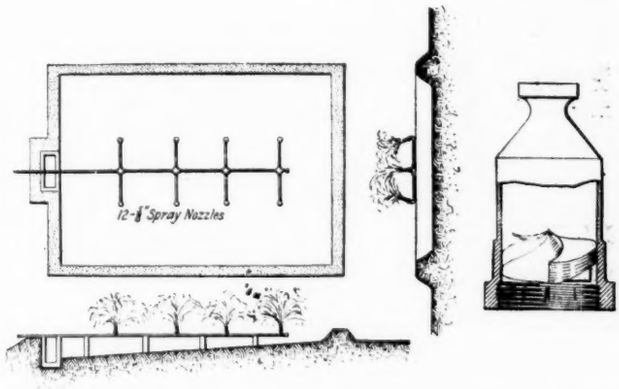


FIG. 2. GENERAL ARRANGEMENT OF SPRAY COOLING POND AND A TYPICAL SPRAY NOZZLE

reduces to about 4 sq.ft. per ton of refrigeration, allowing a temperature range of the water of 15 deg. F. To prevent excessive loss of water, the pond or catch basin should have the embankment at least 15 ft. outside the row of spray nozzles. The nozzles should be about 8 to 10 ft. apart to secure satisfactory results. The spray nozzles may be placed on the roof or above the condenser if suitable louvres are provided to prevent excessive loss of water during winds.

The cooling tower has been successful and popular for many years, and without question will continue to be

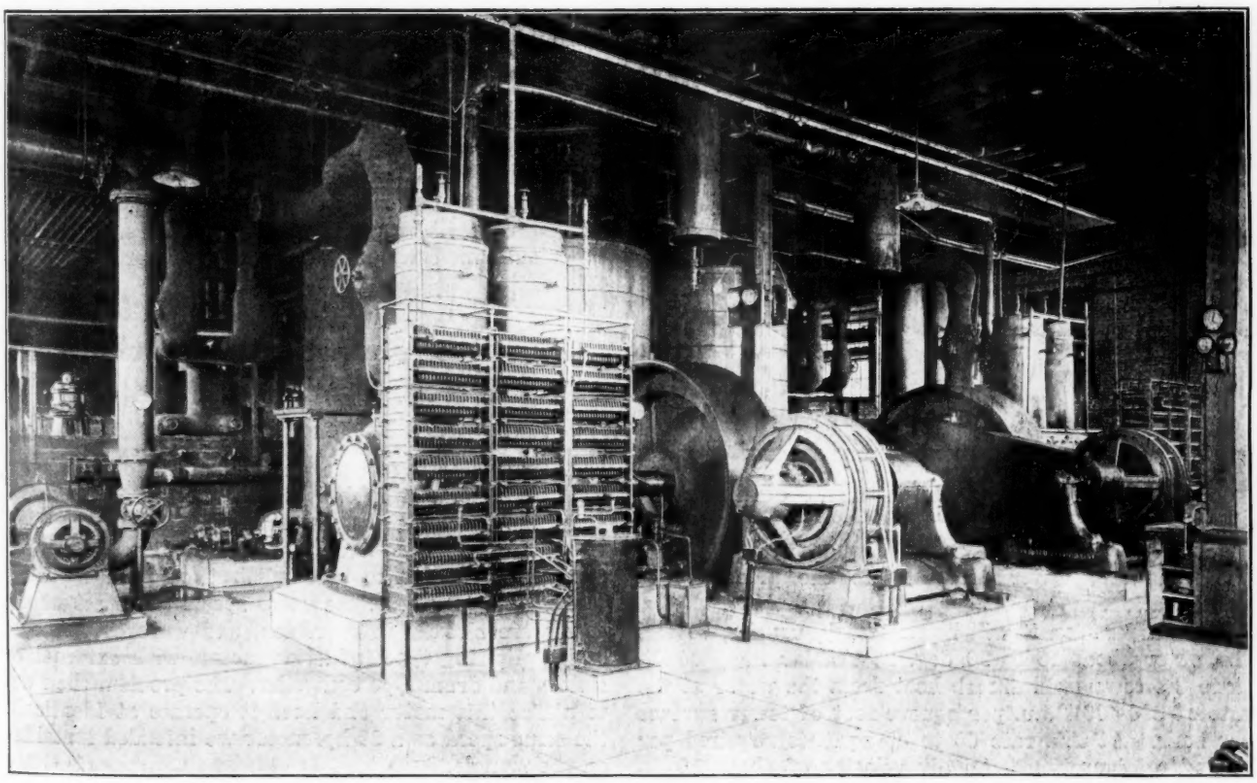


FIG. 3. MACHINE ROOM OF 100-TON ICE PLANT, POLAR WAVE ICE AND FUEL CO., ST. LOUIS

used indefinitely with equal satisfaction. It lends itself particularly to congested quarters, where a cooling pond is out of the question and the spray nozzle cannot be easily arranged. As its name would indicate, it is built in the form of a tower, usually with airtight walls to gain the advantages of the chimney. The object of the tower design is to acquire a natural or forced draft (or both) and to provide a means of securing a large amount of wetted surface kept wet by the condensing water that is pumped in at the top.

The wetter surface may be secured by means of tile, but the usual manner is to form a wooden checkerwork, arranged as in Fig. 4, to prevent undue trouble by warping and so that the wet cross-sectional area will be sufficient to allow the necessary amount of air to pass through. As in the spray nozzle, which requires a finely atomized spray, so in the cooling tower, a thin film of water is required and an air current to evaporate some moisture and to cool the water by the heating of the air.

Action of the Cooling Tower

The action in the cooling tower is as follows: The water is showered over the top grids of the tower, and it descends, dropping from checkerwork grid to checkerwork grid and being exposed all the time as a thin film on the surfaces. The ascending air absorbs moisture and has its temperature increased and finally leaves the tower at a temperature of about 10 deg. F. below the entering warm water of the ammonia condensers, and with a humidity at the exit temperature of about 95 percent. During the passage of the air through the tower some water was evaporated, which cooled

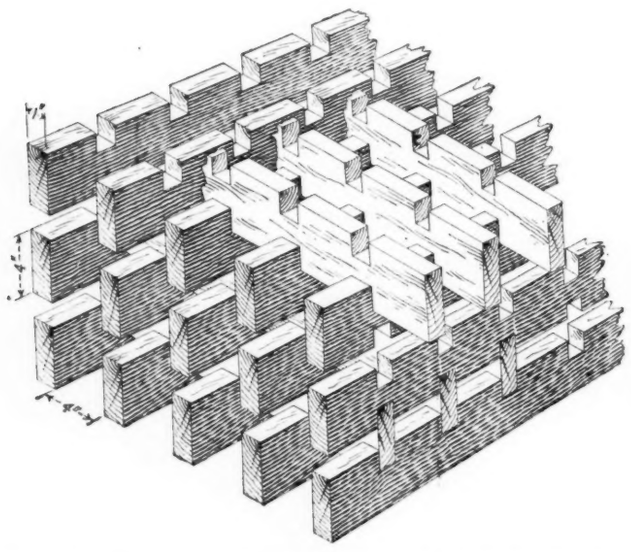


FIG. 4. THE WOODEN CHECKERWORK IN THE COOLING TOWER EXTENDS THE SURFACE OF THE WATER AS IT FALLS, ALLOWING THE UPCOMING CURRENT OF AIR TO COOL IT QUICKLY

the remaining water according to the principles of refrigeration.

In refrigeration it will be necessary, usually, to cool the water about 15 to 20 deg. F. Under these conditions the tower will absorb heat from the water at the rate of 300-400 B.t.u. per square foot of tower surface per hour. At this rate 60 to 45 sq.ft. is required per ton of refrigeration. An air velocity of about 10 ft. per sec. is usually required. In refrigeration a natural-draft tower is generally used, and either the necessary chimney effect is relied on for the creation of a draft, or the design with open sides is used, which relies on the wind to do the business.

It will thus be seen what the function of the cooling water is and what means of making use of this cooling water again is possible. As a means of visualizing the problem better and also of estimating the requirements of new plants, the diagram is added, showing the heat

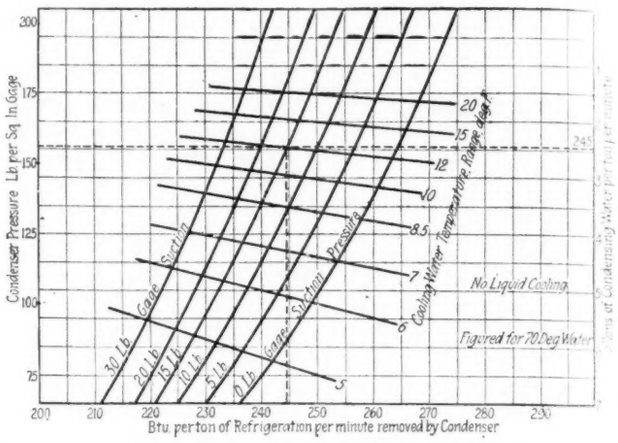


FIG. 5. CHART FOR DETERMINING QUANTITY OF COOLING WATER REQUIRED FOR VARIOUS CONDITIONS OF PRESSURES AND TEMPERATURES OF WATER AND AMMONIA

to be removed by the condenser per ton of refrigeration, and the condenser pressure to be expected in this condition for each temperature range of the cooling water.

For example, if 2.45 gal. of water is used per ton per minute with a suction pressure of 15 lb. gage, the range of the water (the temperature rise in passing through the condenser) will be 12 deg. F., the heat removed per ton per minute will be 244.5 B.t.u. and the condenser pressure will be 156 lb. gage. The diagram is laid out for an initial temperature of the water of 70 deg. F. and no liquid cooling after condensation of the ammonia. Also, the assumption is made that the gas entering the compressor is just dry and saturated—a condition that prevails only with careful operation of the compressor by means of thermometers, at which time the maximum efficiency of the compressor is also obtained.

How Two Alternating-Current Motors Were Controlled in Parallel

By John Grant

A large starch mangle was installed to pull heavy cloth sheeting from a bin located one hundred feet away from the machine, wet, starch and deliver the cloth on a set of dry cans located on a floor directly over the mangle. In order to accomplish this, both machines would have to run at the same speed. The set of dry cans were already in operation, and were driven by a 10-hp. slip-ring type induction motor, with external resistors and drum type controller. The problem then was to utilize this motor and have it operate at identically the same speed as a 50-hp. motor we intended installing on the mangle.

At first thought running the mangle and dry cans at

the same speed looked like a rather difficult undertaking. The drawings of the manufacturer specified a 50-hp. direct-current motor on the mangle and a 10-hp. direct-current motor to drive the dry cans. To have accomplished this successfully would have required the purchase of an alternating-current motor, direct-current generator set, since the power supplied to the plant was two-phase 60-cycle alternating current. This would also have necessitated the removal of the alternating-current apparatus from the dry cans, and altogether would have been an expensive arrangement. After careful consideration it was decided to use alternating-current equipment arranged as illustrated. In Fig. 1 is shown a 75-hp. oil switch *S* with a time-limit overload relay, and a no-voltage attachment *N*. The motor and control equipment is clearly indicated. A set of push-button switches was located at convenient stations on the machines to trip the no-voltage magnet on the main oil switch if necessity demanded it. Bells were installed so that the operators could signal when ready to start up or shut down the machines. This comprised the electrical part of the equipment. The controller handles were taken off, gears put on the controller-cylinder shafts and the handles replaced. Then a 1-in. shaft was installed which extends from the 50-hp. controller, as indicated in Fig. 2, with a gear on each end of the shaft to mesh with a gear on each controller. About one foot from the 50-hp. controller the shaft was cut in two and a coupling installed. A tapered hole was drilled through the coupling and shaft in the upper portion, and a dowel pin was used to prevent the shaft from turning in the coupling. This arrangement is clearly shown in Fig. 2.

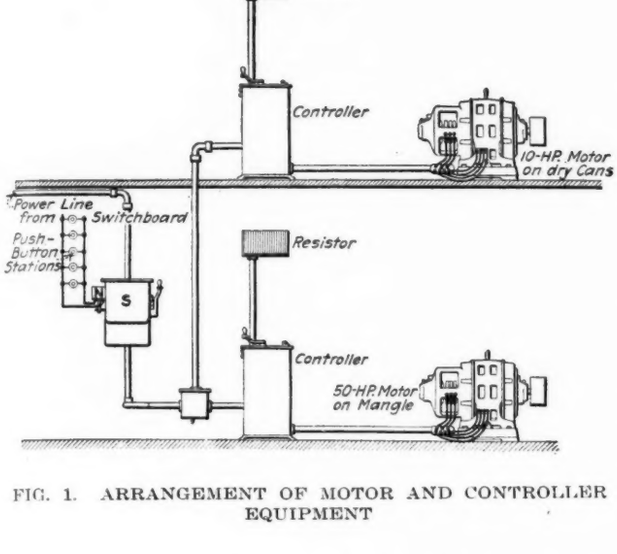


FIG. 1. ARRANGEMENT OF MOTOR AND CONTROLLER EQUIPMENT

To begin operation the cloth must be drawn from the bin and passed through the rolls of the mangle, which of course must operate as a single unit. In order to accomplish this, the main oil switch is closed and then the dowel pin is removed from the coupling and shaft. This will allow the 50-hp. motor to be operated as a single unit. When enough cloth has been passed through the mangle, it is taken up and passed over the first drum on the dry cans; then the 50-hp. motor is shut down and the dowel pin inserted in the coupling and shaft. A signal is given the operator on the dry cans that all is ready, the 50-hp. controller is then closed in on the first notch, and by means of the shaft and gears will also cut in the 10-hp. controller on the first notch, in the same operation. Enough resistance is inserted in the secondary circuits of the motors to make each machine's speed identical and so on until the controllers are on the last step and the secondary resistors are entirely cut out, when the two machines run at practically the same speed.

Considerable difficulty was experienced at the initial starting of this drive, owing to the wide variations of the motor speeds and the difference in horsepower, as much as twenty-five ft. of cloth piling up in front of the mangle. After many attempts at resistor adjustments, which were especially arranged for this drive, the proper values were obtained.

The dry cans are equipped with compensating rolls which take up two feet of cloth or let it out, but so fine are the resistors adjusted that these rolls do not vary three inches at any time either at starting the machines or after they are in full operation. It is worthy of mention that this installation was severely criticized by technical experts when first drawn on paper. Each motor has been carefully checked and tested, when operating as a single unit, and the same test results prevail when they are coupled together.

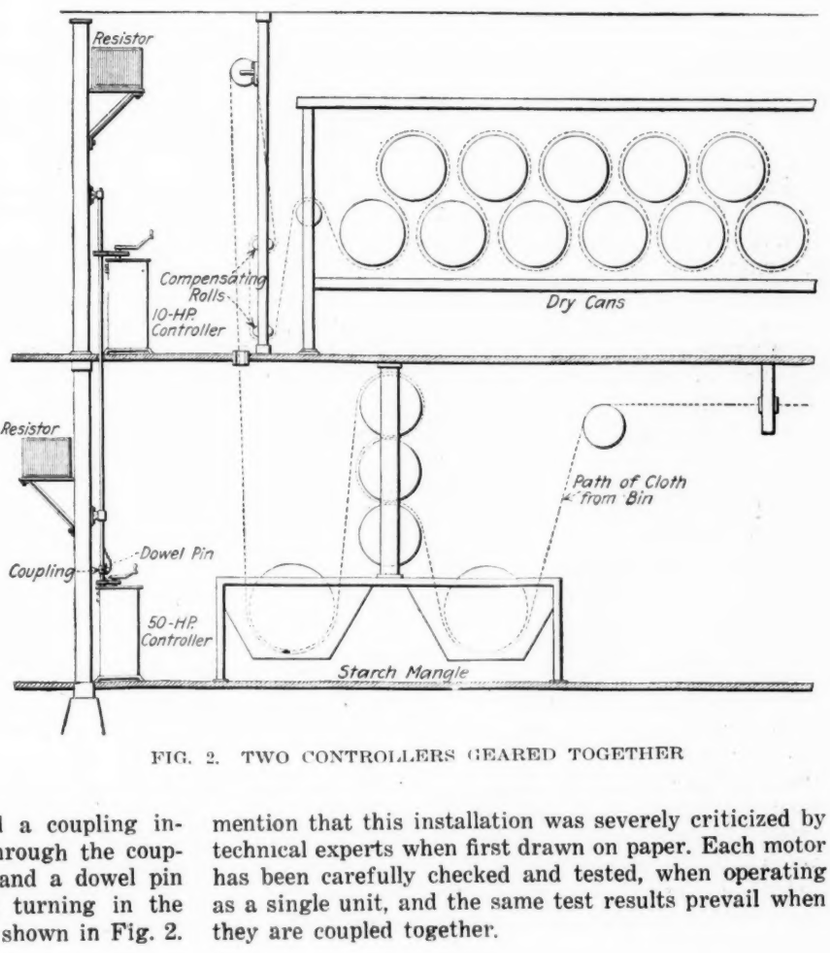


FIG. 2. TWO CONTROLLERS GEARED TOGETHER

Prof. G. F. Gebhardt

Armour Institute of Technology

An educator who takes a father's interest in developing green boys into successful engineers. A genius in devising mechanical means for laboratory testing. An authority in power-plant engineering.

SUMMARIZED in brief, these are the outstanding characteristics of G. F. Gebhardt, who has been a teacher of Mechanical Engineering at Armour Institute of Technology for nearly all of his working life—a period of about twenty years. Close personal touch with his students, a direct interest in each and every one, has been the secret of his success as an educator. He has no regular office hours. His door is always open to the boys, and they feel just as free in coming to him with their personal difficulties as with their regular technical studies. Many a time he has gone to a backward student and at the psychological moment, by a little of that personal sympathy so sadly lacking in larger institutions, has turned him into the ways of success. Out of classes he is a boy with his students, goes fishing and duck hunting with them, gains their confidence and their loyalty, and with it a return in honest, faithful work in their studies. It is an ideal relation for a man in love with his profession and one which only a teacher can enjoy.

In 1874 Professor Gehbardt was born in the Mormon country at Salt Lake City. As public schools of merit were nonexistent at this time, his early education was obtained at the Collegiate Institute, a sectarian school of Presbyterian origin. At the age of sixteen young Gebhardt entered Knox college to take the regular literary course. Two years later he went to Cornell to study mechanical engineering. At the end of the usual period he not only secured his M. E. degree, but, by making up all his literary subjects, was enabled to take the A. B. degree at Knox. Three years later he secured an M. S. from the same college. Contrary to the average opinion of the young engineer, he realized the need for something more than bare engineering. A broader outlook upon life, proper diction in which to express his engineering thoughts and language to clothe his engineering reports were the primary reasons for the literary course, and it is his constant endeavor to impress these same ideas upon his students at Armour. This is why the professor has become a stickler for written reports, as they are means toward a desirable end.

After his college days were over, a choice of professions was to be made. Oddly enough, he had an abhorrence for teaching and the spiritual longing for the ministry was lacking. He decided to become a mining engineer and to be a good one—to start from the bottom. Back to the mountains of Utah he went and worked in the mines in various capacities. For a time he was an ordinary mucker, with the exception that the hardest and most disagreeable tasks were given to the college student. It was a real test of his manhood which he passed with credit and stuck to with determination for over a year. The hard times of '97 and '98 overtook him, however, and in looking around for a new position he finally secured an appointment at Armour as instructor in machine design, thus being forced by circumstances to take up teaching.

It was his thought to make this place a temporary haven until things on the practical side opened up, but almost immediately, in spite of his former prejudices, he found that teaching was the profession that appealed to him. Seeing the green, raw freshmen come in and develop into competent engineers was a fascinating study, and the repetition year after year never chilled his interest. It was only natural that a series of rapid advances came to him. It was not long before he was made assistant professer in machine design, then associate professor, and within three years, professor of mechanical engineering. The date was 1903, and with the one exception of the job in the mountains it has been his life work.

At this time Armour was a regular polytechnic school. The original idea of the late P. D. Armour, the founder of the institute, was to provide a place for the poor boy or girl to learn a trade. For the latter there were courses in cooking, dressmaking, typewriting, etc. For the boys there were the preparatory academy and the engineering courses. It was rather a polyglot mess with indifferent facilities, and the school was getting nowhere. Professor Gebhardt saw the possibilities of building up a great technical institution, and it was in these early days that all side issues were dropped and Armour became strictly a technical college of engineering. It has been his constant endeavor to improve the curriculum and the mechanical equipment until now the institute ranks with the best technical schools in the country.

To build up the proverbial slender income from teaching, the professor has done a great deal of consulting and testing work, never taking a retainer from a commercial concern, but always acting as a free lance on a specific job. In this way he has always maintained a neutral position in commercial work, and is frequently selected as the mechanical expert in court actions or in controversies outside the law. This business has increased to such a point that he has encouraged each and every one of his instructors to specialize on a particular subject, so that he might turn over to them the practice in their line. It is his opinion that it makes them much better instructors. All the new ideas from the commercial field come to them, and the influence is to supplant abstract consideration with the latest and newest thoughts in the field. Incidentally, this work gives them prestige with the students, adds to the remuneration of the instructor and, up to the limit of interfering with classes, is considered an excellent form of training.

Power-plant engineering is Professor Gebhardt's specialty. His book on this subject has been in great demand. It has passed through many editions, the number of copies sold exceeding 26,000. Much of his work recently has been on combustion, and naturally enough, as it is the field where the dollars may be spent or saved. When he has a big job of any kind, the boys are always called in on it. It gives them a chance to get practical experience, to gain confidence and meet men in the profession. The boys are paid a small wage, always by check. It is amusing to relate that many of these checks are slow in returning. The boys frame them as the first money earned, but as they get out in the field, the novelty of earning money wears away, and perhaps the need of it forces a change of sentiment. The checks are cashed and come creeping back to the fountain head, thus performing the double service of furnishing cash and reviving memories.

Professor Gebhardt has done a great deal of research work, including the construction of the machines on which to do the testing. Among the subjects may be mentioned belt transmission, ball-bearing friction, tire-shock absorption and flow of fluids. The Gebhardt steam meter was designed by him, and there have been numerous laboratory machines for testing materials of engineering and special appliances for power-plant testing. His contributions to the technical press have been numerous. In addition to the book already mentioned, he has prepared pamphlets for school use on governors and on the dynamics of the steam engine. He is a member of the American Society of Mechanical Engineers, the Western Society of Engineers and the National Association of Stationary Engineers. In fraternal life he belongs to the University Club, is a Phi Delta Theta and a Tau Beta Pi.

As to hobbies, the professor claims he is just an ordinary individual and does nothing distinctive. We know he appreciates a good cigar, and according to his own statement he would rather sit out in the swamp and shiver shooting ducks than do anything in the educational line. Since the age of nine it has been an annual pastime. He has discovered the fountain of youth. He does not feel like forty-six, nor does he look it. Association with his boys keeps him young. As the older depart, new arrivals hold the average perpetually the same, so a boy he must always remain, with the enthusiasm and vitality of youth combined with the judgment of maturer years.

International "Hot-Flow" Softener

The important difference between hot- and cold-water softeners lies in the provision for sedimentation. Convection currents are set up in hot water by slight differences in temperature, the hot water tending to rise and the cooler water to fall. To obtain the best results in the hot-water softener tank, these currents must be worked with rather than against. This principle has been given attention by the International Filter Co., of Chicago, in the design of a new hot-water softener described herewith.

In Fig. 1 the general arrangement of the softener is shown diagrammatically, with two chambers, *A* and *B*, of equal holding capacity. On top of the softener is an open-type exhaust-steam feed-water heater, in which the entering water goes to a distributing trough at the top and then passes over and through a series of inclined cast-iron trays. Steam enters the heater through an oil separator and comes into contact with the finely divided water in the usual manner.

From the heater the hot water enters the softener through the turned inlet *C* above the baffle plate *F*, the

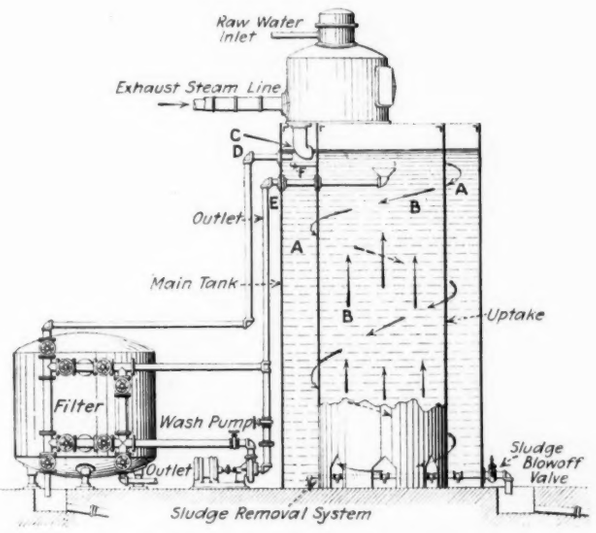


FIG. 1. FILTER AND SECTION THROUGH HOT-FLOW SOFTENER

softening chemicals being delivered to the incoming water at this point. The turned inlet and baffle plate cause the incoming water to flow in a horizontal direction around and downward to the outer annular chamber *A*, automatically providing the agitation that brings the softening chemicals and the water into contact. At the bottom the water flows through the inverted V-shaped openings from the outer chamber *A* into the inner chamber *B*. The water is drawn off through the outlet pipe *E* from a point near the top of this chamber.

Although but twenty to thirty minutes are necessary for the chemical reactions and sedimentation, the softening tank has a one-hour holding capacity.

The outer chamber *A* provides for the mixture of the incoming water and the chemicals. All the commotion set up is restricted to the water in this chamber, and the outer chamber of water serves as a blanket of insulation for the inner or uptake chamber, permitting no cooling of water in the uptake or the setting up of convection currents.

In the chamber *B* the water rises slowly, permitting the separation of the sludge from the water to become completed, although some of the sedimentation takes place in the outer chamber.

A standard part of the softener is a filter. The softener supplies hot water to wash it, and provision is made for its return to the outer chamber of the softener, where it is allowed to resettle and pass through the usual process, the heat in the water being saved. The circulation for washing is set up by an auxiliary pump, the flow being upward through the filter bed instead of downward as when filtering. Neither the softener operations nor the boiler-feed supply is interrupted while the filter is being washed.

Softening of the water is effected by treating it with hydrated lime and soda ash supplied from a chemical mixing tank and feeder.

Hard water enters the softener through the head chamber above the heater, the flow being regulated auto-

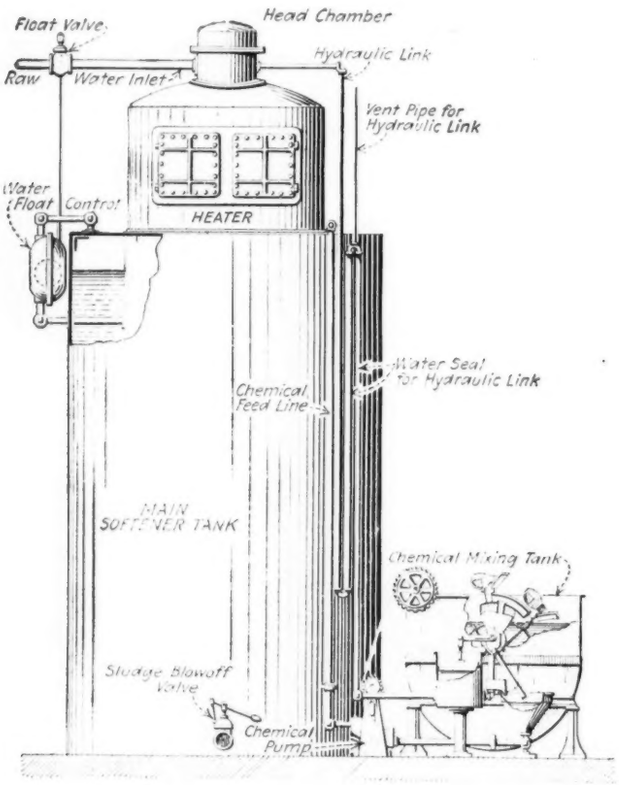


FIG. 2. SOFTENER TANK AND CHEMICAL FEED

matically by a float valve in the supply line. The water flows into the heater and is divided into two proportionate streams; the larger stream flows into the heater and the smaller quantity flows into the hydraulic link pipe shown in Fig. 2. As the head or pressure of the incoming water governs the flow of both, the two streams always flow in proportion to each other. If more water flows into the heater, proportionately more water flows into the hydraulic link pipe; if less water flows into the heater, a correspondingly smaller amount flows into the hydraulic link. This hydraulic link conveys a small stream of water to the chemical float control independent of the back pressure in the heater and head chamber, and as the rate of flow of the water in the hydraulic link is always in proportion to the main flow of water into the heater, the smaller stream of water is used to control the chemical feed.

From the float control the discharge is a modulated orifice tube that keeps the level of the water in the float control in relation to the main flow of water into the heater. A greater flow of water into the heater causes a higher water level in the float control and a lesser flow a correspondingly lower level. A float which rises or falls with these changes in water level in the float control moves the cutoff shield over the collector funnel in the chemical tank. If the softener is operating at half capacity, the cutoff shield covers half of the mixture picked up by the revolving cups. Thus, at any rate of operation, the cutoff shield deflects from the collector funnel all or part of the chemical mixture except that required.

The chemicals for twelve to twenty-four hours operation are weighed and put into the chemical tank, which is then filled with water. The mixture is then agitated to keep it circulating in an up and down motion in all parts of the tank and maintain a chemical mixture of uniform strength.

The greater proportion of the sediment or sludge formed settles to the bottom of the main tank and is blown off through the pick-up pipes and the main sludge blowoff valve, which is opened two or three times each day.

The hot-flow softeners are built in graduated standard sizes with capacities per hour ranging from 900 to 18,000 gal. In boiler horsepower based on 30 lb. of water per hour the listed capacities range from 250 to 5,200 gal. Special sizes up to 10,000 boiler horsepower are built, using the same principles of construction and operation.

Denmark is at present supplied from 497 central stations having a total output of 108,000,000 kw.-hr. per annum. The net sale to 205,000 consumers is 30,800,000 units for light and 54,700,000 units for power. The average net cost per unit in 73 towns is 4½d., in 387 villages 7½d., and in 37 agricultural districts 3¾d. The high cost in the villages is chiefly due to the load factor, which seldom reaches 0.10, and in a smaller degree to the high cost of fuel. With regard to future developments, it appears, according to the *Technical Review*, that a scheme is being considered which will enable a supplementary supply of electrical energy to be obtained from Norwegian waterfalls. The distance from the nearest suitable falls to Copenhagen is about 75 miles, and it is proposed to send 26,000 kw. at a pressure of 50,000 volts by an overhead transmission line running through Sweden to Malmô, and thence by submarine cable across the Sound to Copenhagen. The engineering difficulties in connection with this proposal are easily overcome, but the economic question presents some difficulty, as a low load factor would require a very expensive transmission line, and necessitate high prices to consumers. The estimated requirements of the country, provided cheap energy can be supplied, are about 450 million kilowatt-hours per annum.

The proposed extension of hydro-electric projects in Japan will involve the building of about one thousand miles of high-pressure transmission lines within the next two years. The use of aluminum instead of copper for the transmission cables is considered.

EDITORIALS

Efficient Utilization of Water Powers Already Developed

ACCORDING to the United States Geological Survey's estimate of 1915, seventy-five per cent of the maximum potential water power of the New England States is developed. This figure was also used in the National Electric Light Association's Water-Power Development Committee's report submitted at the Pasadena convention in May of this year. Taking these figures at their face value, it is apparent that little additional water-power development may be expected in this district. However, when the way that many of these developments are made is considered, especially in the industrial centers, it is evident there are still large possibilities of future water-power development in New England, and the committee's statement regarding this district that "future development will consist chiefly in a more efficient utilization of the water powers already developed" has a real significance.

A large percentage of the water-power developments in New England have just grown, without any consideration being given to efficient operation. The first manufacturer on the site built a dam and utilized a head that best suited his needs. The next manufacturer did likewise or entered into the same agreement with the party having prior water rights. This process continued until all available water power at a given site was utilized, after which further power, if needed, was developed from fuel. Water-power development of this kind has resulted in a very inefficient use of the available energy in the water. Not infrequently is it found that water powers have been developed in three or four low-head projects, with a large number of small inefficient waterwheels, with the result that probably not more than twenty-five per cent of the power is obtained, that would be possible if the total head were utilized in a modern development. Another source of large loss is in the gears, lineshafting and belts used to transmit the power from the waterwheels to the manufacturing machinery. The co-ordination and unification of these numerous inefficiently developed water powers into a comprehensive system would have a far-reaching effect in the solution of New England's power problems. Nobody is to blame for the inefficient way many of these water powers have been developed; it is a case where industrial expansion has outgrown the methods that were perfectly satisfactory forty or fifty years ago, and an adjustment must be made to meet the new condition.

There are many problems to be solved in the redevelopment of these water powers, and probably none is more serious than the location of some of the plants that utilize large quantities of water in their manufacturing processes. Unless these plants are located above the dam or below the power plant, large quantities of water will have to be used for industrial purposes that should be available for power development. This problem also would exist with steam plants operating condensing. However, water that is available for manufacturing processes under a natural head would not require power for pumping, and if this water afterward could be used for power purposes under part of the total head, its efficiency of utilization would be comparatively high. There is also the possibility of taking the water directly from and returning it to the penstock where a closed system is used, such as in a condensing equipment. Be these problems what they may, the high price of coal will in no distant future cause them to be given serious consideration. Furthermore, before we as a nation can say that we are making an honest effort to conserve our natural resources, many of our water powers must be redeveloped for a much higher efficiency than at present obtained. When it is possible to obtain ninety to ninety-three per cent of the total energy in the water, we should not be satisfield with twenty-five or thirty per cent.

Conventions and What We Can Get Out of Them

MAY and June are convention months. We have had the joint meeting of the American Societies of Mechanical, of Refrigerating and of Heating and Ventilating Engineers at St. Louis. We have had the Organization Conference resulting in the launching of the American Federated Engineers Societies at Washington. We have had the American Federation of Labor meeting at Montreal. The list might be extended almost indefinitely. Of course we must not forget the two big political conventions for the nomination of Presidential candidates, but the daily press has given all kinds of information (?) about them.

The conventions that the readers of *Power* are most interested in are those of the various engineering organizations. The custom of presenting and discussing technical papers at such meetings produces a large amount of high-grade engineering literature each year, and there are few of the technical-society programs that do not have at least one paper of use to anyone engaged in the production or use of power.

It is unfortunate that every man cannot attend such conventions. A large part of their value lies in the personal contact with other men from other parts of the country. When you hear first hand of the other fellow's troubles, problems and successes, your own troubles seem less, your problems easier to solve and your success nearer.

The men who stay at home, however, can and should get a great deal out of these meetings. Every technical journal tells, in its news columns, of the general happenings at those gatherings in which its readers will probably have an interest. More important, however, are the abstracts of the papers and discussions. In this connection the stay-at-home has perhaps an advantage. He has the story boiled down so that he gets the important points with a minimum amount of time spent.

One big feature of the engineering-society conventions, however, is that there the newest ideas are usually presented. The easiest way to keep just a little ahead of engineering practice is to watch carefully what is

offered at such meetings. True, papers are often presented which are so far ahead of good practice that practice never catches up with them, but the man who is never ahead is always behind. It is also true that many of the papers are presented by representatives of manufacturers and are really presented as part of advertising campaigns. On the other hand, it is equally true that such so-called advertising papers describe some new apparatus, process or idea and so are of value to the reader. They must also be reliable and accurate, for each manufacturer knows that his competitors will read his paper and present discussions which will expose any false statements or mistakes.

It is well worth your while, then, to read and study the abstracts of such papers and get your share of the benefits from meetings that are held mainly to help the engineers and, through them, the public.

Fuel Economy Still Vital

DESPITE the urgent need for it at this time, one does not hear much about fuel economy, particularly in power plants. It may be that power-plant men are so busy practicing it that they have no time to talk about it. This is, of course, true in many cases, but the quality of the fuel that many plants now get causes the engineers no little worry to burn it at all, to say nothing of burning it efficiently. We must not lose sight of the seriousness of the fuel situation. Coal is too costly these days to warrant neglect in its use no matter who pays for it. It is every bit as necessary to fire intelligently, to stop preventable losses in the boiler room, to consume power savingly, as at any time during the war.

In the large modern station, coal economy is, in greatest part, a matter of design—design that reduces to a minimum the human equation. But in the far greater number of plants in the country the men in the power plant, the engineers and firemen, determine ultimately whether fuel shall be used economically or woefully wasted. Upon these men there rests a truly great responsibility. They owe it to themselves, to their country and to their employers to make every pound of fuel do its utmost.

Steam-Turbine Development

WE FREQUENTLY hear comments on the very rapid development of the steam turbine as compared with the early progress of the reciprocating steam engine. The latter machine began as, to modern eyes, a very crude piece of apparatus and was improved only by slow and tedious steps. While the first steam turbines were built long before reciprocating engines, no real commercial use was made of them until within very recent years. When engineers finally did turn their attention to turbines, progress was so rapid as to be almost bewildering.

There are a number of reasons for this difference. The engine could develop no faster than the steam boiler and the various auxiliaries. The turbine designer found boilers, piping, condensers, etc., already at hand and could focus his attention on a single problem. Modern methods of machine-shop practice and modern steels, bronzes, etc., were not available to the early engine builders as they were to the turbine builders who came so much later.

Probably one of the greatest factors in the rapidity of turbine progress is to be found in the knowledge possessed by modern engineers of the properties of steam and the theory of the production of power by means of heat. The first steam engines were built almost by guesswork and had been in use some time when Sadi Carnot laid the foundations of the theory of thermodynamics. After him came a long line of men who labored in the physical laboratories and solved complicated mathematical problems. A great deal of their work was looked upon as purely theoretical and of little or no value to the man who had to build or operate steam engines. Without this work, however, we would today probably be using engines not much better than those of Watt.

The turbine designers found much of this work already done for them, but there are still many unsolved problems. The article in another column under the title "Supersaturated Steam" suggests some of these problems. Is the steam in a turbine in a state of unstable equilibrium? If this is the case, can a rational workable theory be developed? Scientific papers already published show that the "theorists" are at work on these problems, and judging by the past the solutions will probably be found. Wonderful progress in development has been made, but who can tell what will yet be accomplished as one by one these problems are solved? Meanwhile, the engineer, operator or designer who wants to make good must take an interest in such things as are often spoken of as "highbrow."

Storage-Battery Development

SOMETIMES the development of a special branch of an industry takes place so quietly that other branches of the same industry fail to observe the change. Often even those in the special branch that is changing are to a large extent unconscious of what is happening. All engineers remember that only a short time ago a storage battery was considered a delicate and complicated part of the equipment of the power plant where there was such equipment at all. Today they are operated successfully by thousands of people who know nothing about engineering. No doubt further applications of the storage battery in power stations will develop as the demand for reliability of operation increases, and it would be well for those interested in power-plant operation to keep in mind the possibilities of this form of equipment.

A headline reading "Airplanes for Mine Rescue Work" was rather startling until we read further and learned that the Bureau of Mines is planning the use of flying machines to carry rescue workers and apparatus from the various stations of the Bureau to the mines where they may be needed. The element of time is a big item in mine-rescue work, and this new use for airplanes promises another advance in the conservation of human life.

The recent orders of the Interstate Commerce Commission calling on various Western railroads to return stated numbers of open-top cars to the Eastern roads promises some help in the coal situation. If more coal cars come to the mines and if the assigned car problem can be solved, we may all be able to get at least a part of next winter's coal into the storage yards before cold weather comes.

CORRESPONDENCE

Comparison of Pulverized-Coal Tests

Of the numerous comments made on the pulverized-coal tests at the Milwaukee Electric Railway and Light Co.'s plant, that by Paul W. Thompson is, to my mind, the most interesting and instructive.

In all cases an analysis of such an installation involves the element of comparison, which in turn necessitates the use of a standard for the purposes of such comparison. If the standard of comparison is a poor one, naturally the test being compared will show better than if the standard of comparison is a good one. To me, the entire matter of these pulverized-fuel tests hinges upon the standard of comparison used and the deductions that are drawn from such comparison.

In this case the underfeed stoker is that used as the basis, and therein lies a possible opportunity for a complete revision of engineering opinion.

As Mr. Thompson rightly says, there are certain "losses that are inherent in stoker practice, such as breakdowns in the stoker itself, breaking up clinkers, loosening clinkers, continually watching the fire to maintain correct and uniform thickness, watching the gas passes of the boiler for large sparks indicating the carrying away of combustible, dumping, and many other operations are necessary to stoker practice."

The trouble with the engineer of today is that he assumes that the underfeed stoker, with all these inherent defects, is the proper and sole basis of comparison. I have more than once stated that any stoker that possessed the defects of clinker formation, periodic dumping, uneven thickness of fire, fuel-bed disturbance, etc., was fundamentally wrong and could not endure under the fierce light of the competition of today. Under no conceivable circumstances can any stoker, whose fundamental design involves these things, operate at such high rates of combustion as to produce melting temperatures in the furnace or fuel bed and give satisfactory results. Modern practice demands rates of combustion much higher than can be secured without the formation of clinkers in the underfeed stoker, and incidentally much higher capacities than the test at Oneida Street proves is possible without the production of destructive furnace temperatures.

With the prices of power-plant equipment as they are today, boiler-heating surface must be worked to a very much higher degree than ever before, and rates of steaming corresponding to 150 per cent of rated capacity are going to be considered as a thing of the past. Without any doubt the modern boiler will continuously, safely, and economically generate a boiler horsepower from 3½ sq.ft. of heating surface, and furnace temperatures up to 2,700 or 2,800 deg. F. must be endured if the right efficiency is obtained. Any coal-firing system which will not stand up under these requirements is wrong and cannot last.

Instead of comparing the Oneida Street tests with an underfeed stoker producing a gross efficiency of 76 per cent, it will be necessary in the future to compare it with a method of stoking which will produce a gross efficiency of 80 per cent and without the interruptions to efficiency resulting from the before-mentioned inherent stoker losses. Someone will then have to do some figuring to justify the additional cost of $20 per boiler-horsepower.

I suggest that before long we will have an opportunity of making a comparison of these tests with a stoker that can produce continuously 300 per cent of rating without clinker formation, periodic dumping, breakdowns, or the attendance of highly-skilled operating help.

JOSEPH HARRINGTON.

Chicago, Ill.

California Boiler-Law Requirements

On page 697, of the May 4 issue of *Power*, there is shown a drawing of California boiler-law specifications in which the lower connection to the water column is shown entering the shell at the second row of tubes from the bottom. I have yet to see a water column so connected or to meet an engineer who would advocate such a connection.

We keep the lower connection as high as between the first and second rows of tubes from the top in order to make the columns of water that balance each other on the inside and outside of the boiler as short as possible.

Increasing the length of these balancing columns by lowering the bottom connection increases the inaccuracy of the water level shown by the glass, because the boiling column of water inside the boiler is lightened by its content of steam and will stand higher than the outside column, in the connections and mounting, which is solid water.

If at a certain state of intensity of ebullition, 13 in. of water inside the boiler balances 12 in. of water in the outside connection, then it would require 26 in. to balance 24 in. and 39 in. to balance 36 in.

Thus, by lowering the bottom connection until a 1-ft. column was lengthened to a 3-ft. column, we have increased the inaccuracy of the water level showing in the glass from 1 inch to 3 inches.

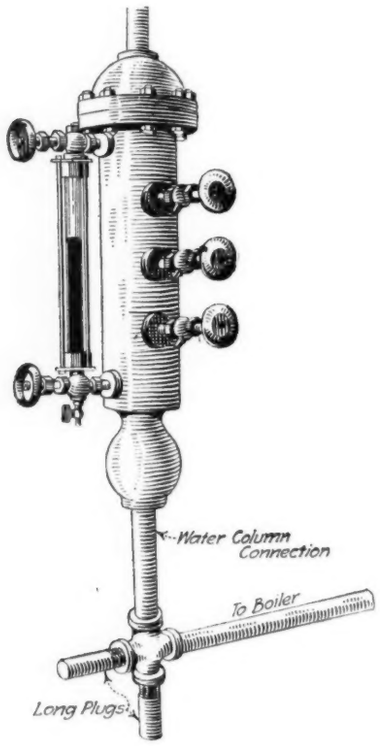
R. MANLY ORR.

Vancouver, B. C.

Plugs in Water-Column Connections

In the article, "Three Power Plant Kinks," page 820 of the May 18 issue of *Power*, Mr. Little says that he would apply two long brass plugs to the water-column connection.

If the A.S.M.E. Code and other codes are consulted, it will be found that the lower water-column pipe must be provided with a drain cock or valve, with a suitable connection to the ashpit or other safe point of waste.



PLUGS IN WATER-COLUMN CONNECTION

The water-column blowoff pipe should be at least ¾ in. The object of this valve is to drain the water column as more or less sediment is bound to collect in the bottom and, if it is not drained off, will plug the water-column pipe.

CHARLES W. CARTER, JR.

Olean, N. Y.

Why the Piston Would Not Come Out

Several years ago it was my experience to wonder why we could not remove the piston of 30 in. diameter low-pressure cylinder. From the start this engine ran poorly and the cylinder began to cut and score. We laid the trouble at first to poor lubrication, but later came to the conclusion that the two metals of the piston and cylinder were not homogeneous. It was a case of take the piston out at least twice a week, and oil by the quart had to be pumped into the cylinder at starting and stopping.

Finally, it was decided to rebore the cylinder and put a dovetailed ring of babbitt metal around the piston. The load was transferred and the low-pressure head was removed. The locknut on the crosshead end of the piston rod was loosened, and a socket wrench was fitted to the nut on the piston rod, at the piston end, but the piston rod would not unscrew. We made a clamp for the rod and used the trolley falls on this clamp and pulled at the same time on the socket wrench, but without avail; the piston rod still refused to budge. Up to this time we had probably removed that rod at least twenty times without trouble.

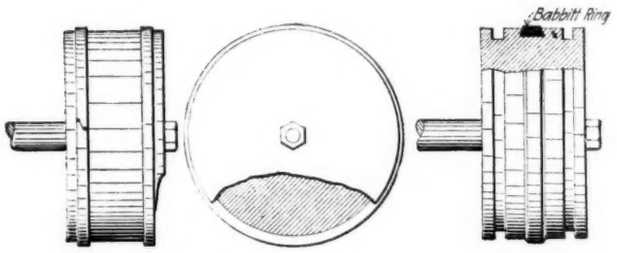
Some wisehead in the crowd suggested that we turn the engine just as slowly as possible by means of water power (of which we were well supplied) and try to unscrew the rod during this performance. This worked successfully for a short period. The piston and rod turned easily until we got the piston almost out to the counterbore. Then the man doing the turning was told to stop, but he gave just one more pull for good measure and the ring dropped over the counterbore. The piston kept right on going and, consequently, a portion of the outside ring groove was broken off.

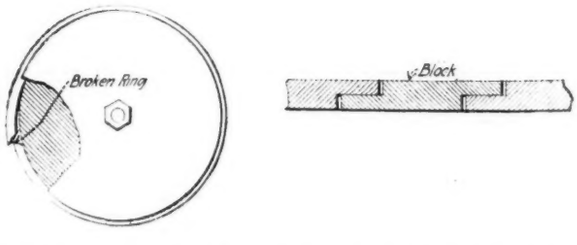
We could not unscrew the rod any more, and so after measuring the amount already gained, we decided to saw the rod off close to the crosshead. With the rod clear from the crosshead it was only a few minutes' work to get the piston out, and then we found the cause of our trouble.

As the rings rattled at times, we had concluded that they turned and that when the opening came next to the steam port, the steam got in the ring opening and caused them to slam. We had, therefore, put a block in the ring groove at the bottom of the piston to keep the ring from turning.

As this stopped the noise, we concluded that our theory had been right, but this block in the bottom of the piston was what caused our trouble.

The ring next to the crosshead had broken and when we tried to turn the piston the ring rode upon itself





BROKEN PISTON, BABBITT RING, BROKEN RING AND WOOD BLOCK

and formed a grip on the cylinder. The scores in the cylinder engaged the broken ring, and so we could not turn the piston. After the cylinder was rebored and the dovetailed ring of babbitt metal was in place, everything worked well. The illustration shows the defects mentioned.

The piston rod was a trifle short, but as it had been fully long enough, we concluded to use it and it worked all right. We welded the broken piston.

New York City. C. W. PETERS.

Fitting Crank-Rod Brasses

A smooth running engine, operating with maximum efficiency and at a minimum cost requires that all repairs and adjustments made to the wearing parts be skillfully carried out and with due consideration to the alignment of the various parts, which, if neglected, may result in a heated bearing, heating and pounding of the crankpin journal, or possibly a knocking in the cylinder.

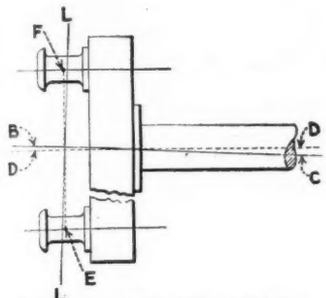


FIG. 1. PATH OF CRANKPIN TRAVEL

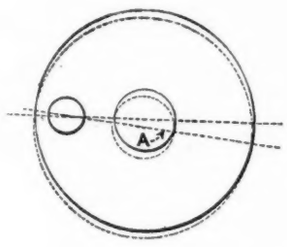


FIG. 2. DROP OF CRANK SHAFT

Suppose that a knock developed in the main bearing of the engine and the engineer adjusted the brasses to take up lost motion without consideration being given to the alignment of the crankshaft. If the bearing had worn low enough to cause the crankshaft to drop to the position of *A*, Fig. 2, there would be trouble in time with the crankpin brasses. The effect of such a drop will be seen by referring to Fig. 1, where *BC* represents a line through the center of the crosshead pin. The line *DD* represents the center line of the shaft, which is out of the parallel with the line *BC*, due to a worn crankshaft bearing. The line *EF* represents the center line of the crankpin when in its top and bottom or half-stroke position. Line *LL* is a line at right angle to the crosshead pin represented by the line *BC*. The line *LL* being at right angle to the line *BC* would represent the path of rotation of the crankpin were the crankshaft in horizontal alignment, but as the crankshaft is not in alignment, that is, *DD* and *LL* are not at a right angle one to the other, the path of rotation of the crankpin is from *F* to *E*. The center point *F* of the crank thus falls on one side of the line *LL* at the top position and on the opposite side of the line *LL* in its bottom position, as represented by the point *E*. If we couple up the crank rod to the crosshead pin and put the crankpin brasses in the rod end, but not coupled up to the pin, and lower the end of the rod onto the crankpin, it will be found that the flanges of the brasses will fall to one side of the crankpin when the crank is in its top position, as shown in Fig. 3, and will fall on the opposite side end of the crankpin when the crank is in its bottom position, as shown in Fig. 4.

Suppose the foregoing conditions actually exist and the connecting rod is connected up, then the rod would be twisted twice for each revolution of the crankshaft. On rotating the engine the straining would gradually diminish as the dead center was reached and then increase again on passing the dead center. This binding of the brasses would cause heating of the crankpin brasses, and if there were side play pounding would result.

Suppose that in making the vertical adjustment to the crankshaft the engineer had inadvertently disturbed the horizontal alignment of the shaft, throwing it out of its original or normal position *G*, into the position shown by *H*, Fig. 5, heating of the crankpin brasses would be the result. This will be understood by referring to the illustration, where *II* represents a true line through the cylinder bore and guide, *G* represents the normal position of the crankshaft and *H* the position of the shaft which is not at a right angle with the line *II*. The line *J* represents a line through the center of the crosshead pin which is in alignment or at right angle to the line *II*. *K* is a point central to the length of the crosshead pin. If the crosshead end of the connecting rod is uncoupled, the rod will spring to the position shown by the line *M* when the crank is on the dead center. If the crank end of the connecting rod is uncoupled from the crank pin and then lowered, the rod will fall to one end of the crankpin as shown in Fig. 6 and on the other end of the pin as shown in Fig. 7 when tried with the crank on the other dead center with the crankshaft out of alignment, as shown by the lines *A* and *B*. With the connecting rod coupled up under the foregoing conditions, the rod would be bent or sprung, and as a result heating of the connecting-rod brasses would be sure to follow.

Serious trouble may be caused by the faulty fitting in of new connecting-rod brasses or owing to faulty repairs to the existing brasses. Suppose that a pair of new

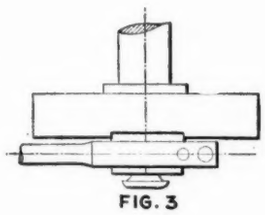


FIG. 3

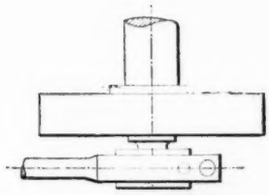


FIG. 4

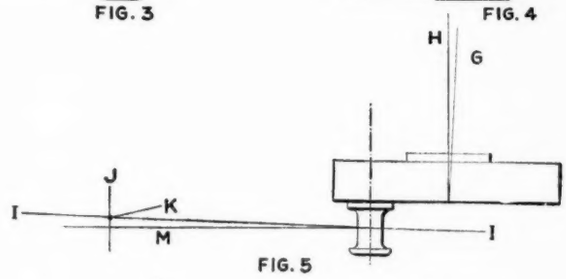


FIG. 5

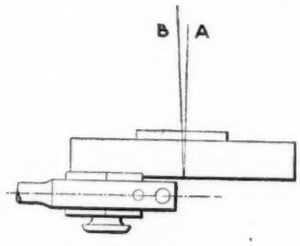


FIG. 6

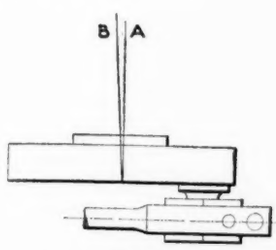


FIG. 7

FIGS. 3 TO 7. SHOWING NATURAL POSITION OF CRANK IN RELATION TO FAULTY ALIGNED CRANKSHAFT

brasses are to be fitted to the crank end of the connecting rod, the side and inside faces of the rod should first be lightly smeared over with red lead. The brass should then be fitted in the rod, interposing a piece of hard wood so as not to damage the brass by the blows of the hammer when knocking the brass in and out of the rod end. When the brass has been partly fitted in, it should be tested with a try square *S*, as shown in Fig. 8, to ascertain if the fitting is being done true and square with the point face. It should also be tested with calipers at *O* and *P* for parallelism, as it is possible that in fit-

ting the brass it may be too loose on the inside face of the rod, as shown at *Q*, Fig. 9. An additional blow with the hammer, however, may cause the brass to tilt over to the side and the red lead marking may thus give a false indication of the fit. The brass must also have a true bed at the bottom of the rod, for if the fit at this point is neglected and is as shown at *R*, Fig. 10, then, when the wedge is adjusted the brasses will spring in

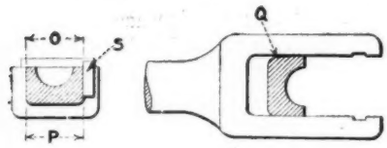


FIG. 8. SQUARING BRASSES

FIG. 9. FAULTY TOP FIT

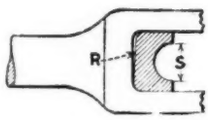


FIG. 10. FAULTY END FIT

at the point *S* thus gripping the crankpin and causing it to heat. When properly fitted both brasses must come together true and square with the point faces. After the brasses are bedded to the crankpin and the rod has been adjusted to the crankpin it should be tested for alignment with the crosshead, and if the rod end falls true and square in the jaws of the crosshead the rod is in alignment.

In making repairs to the existing crank brasses the rod may be thrown out of alignment. Suppose the engineer finds, on examination of the brasses, that the bearing faces are cut or scored and then proceeds to file out the cuts, but in so doing he may not keep the bearing face true with the original base, or true with the side faces of the brass.

Should this occur and the rod be coupled to the crankpin, the other end of the rod would not fall true in the jaws of the crosshead, and if the rod is coupled to its bearings heating of the brasses will result.

A knocking may also develop through faulty work on the crank-end brasses. It sometimes happens that a ridge has formed at the end of the crosshead travel and also in the cylinder at the end of the piston travel. When reducing the brasses to take up the play, the engineer may find it necessary to line up the brasses, and if due consideration is not given the length of the connecting rod may be altered, thus causing the crosshead and piston to travel farther at one end of the stroke, striking the ridge and setting up a knocking. It thus becomes obvious that repairs to the existing plant should be skillfully executed and the alignment of the various parts kept intact.

When making repairs to the main bearing the following method may be used for testing the horizontal alignment: Take an adjustable spirit level and lay it on the guide path if it be a flat face or on a machined part on the cylinder top and adjust the level until the bubble stands in the center. Then lay the level on the crankshaft and adjust the bearing until the two levels coincide. For testing the horizontal alignment the connecting rod may be used if it is known that the bore of both end brasses are parallel with each other.

Uncouple the large end from the crankpin, putting back the brasses in the rod, and tighten up the crosshead end adjustment so that the rod can just be moved and lower the rod end on the crankpin with the crank on the dead center. Then try the rod in the same manner with the crank on the other dead center and make the side adjustment of the main bearing brasses until the rod falls true between the collars of the crankpin when tried on both dead centers.

The method suggested for aligning in case of repairs to the main bearing must *not* be taken as the correct method of aligning, but as a temporary measure, the correct and true aligning of the engine being left to a more convenient time when the engine is shut down for general repairs.

THOMAS W. AIRCY.

Lincolnshire, England.

Organized Power-Plant Employees

I have read some good articles on power-plant organization, but I think something more might be said along such lines. Having gotten the plant force on the job, they all start in on their individual work, each trying to do his best until someone starts doing things. The word is passed along, and soon there is bad feeling between this and that one.

This is one of the worst things that can get into an organization of any kind, especially in power or industrial plants. Co-operation between the men on the job and the chief engineer, chief electrician and master mechanic is of the first importance, because without it the strongest organization will eventually break down. If the chief and the master mechanic are not pulling together, the men soon realize it and things go from bad to worse.

Sometimes a man who has had a limited amount of actual experience is placed in charge of a plant, and he is sure to have his troubles unless he has the co-operation of the heads of his several departments. He should take them into his confidence regarding the working of the plant.

Any man who has worked himself up from fireman to the position that enables him to obtain his "Gold Seal" from the Massachusetts District Police, giving him the right to have charge of any steam plant in the state, has a right to expect some degree of confidence from his superior.

I am sure that if the one in authority were to discuss with his men the changes that he expects to make and how they might affect the operation of the plant, thus giving his men a part in a real man's job, he would find that it would enhance the good feeling of all concerned, if nothing more.

I know that most engineers and power-plant workers are students and that they are right with the work all day and all night seven days a week, and furthermore, they are close observers of cause and effect and their good will is worth having. A chief engineer is in charge of a plant and is expected to produce results, therefore, he should be consulted regarding changes that are to be made. We all like to say "I did it," but it is much better to have the conditions such that the men can say "we," for one man cannot accomplish much alone. It takes all the fellows from the coal passer to the manager to keep things going right. It does not matter what your rating is, it is what you can put into the plant organization that counts. One weak link in the chain has caused the failure of many strong organizations, but when all pull together, each in his place, and each one is made to feel that he is a part of the whole organization, there will be ideal conditions.

Webster, Mass. M. W. CARTEL.

INQUIRIES OF GENERAL INTEREST

Relative Length of Pump Cylinders—Why is the water cylinder of a pump made longer than the steam cylinder?

J. P.

The water cylinder of a direct steam pump needs to be longer than the steam cylinder so there may be ample space for the water passages without obstruction by the water piston when the steam piston is at either extreme end of its cylinder.

Size of Flue for Return-Tubular Boilers—What should be the size of a circular steel flue chimney connection 60 ft. long for two 72 in. diameter x 18 ft. return-tubular boilers?

W. N. F.

A safe rule to follow in figuring flue areas is to allow 5 sq.in. of cross-sectional area per boiler horsepower, and assuming that 300 boiler horsepower is to be provided for, the cross-sectional area should be 1,500 sq.in., or practically 44 in. diameter.

Gallons per Inch Depth of Vertical Sided Tank—What number of gallons is contained per inch depth of an oil tank 10 ft. ½ in. in diameter with vertical sides, and what should be the diameter to contain 50 gallons per inch of depth?

J. L. P.

One U. S. gallon is 231 cu.in., and the tank 10 ft. ½ in., or 120.5 in. in diameter would contain $120.5 \times 120.5 \times 0.7854 \div 231 = 49.37$ gal. per inch of depth. To contain 50 gal. per inch of depth the diameter would need to be $\sqrt{231 \times 50 \div 0.7854} = 121.26$ in., or practically 10 ft. 1¼ in.

Rotary Converters in Parallel—In our plant we have two rotary converters; one machine is a six-phase and the other a three-phase unit, operating at 600 volts on the direct current side. Can these two machines be connected in parallel?

C. T.

There is no reason why these machines cannot be connected in parallel. Of course the connection will depend somewhat upon their type and method of voltage regulation. It will also be necessary to provide protection to prevent one machine from motorizing the other. This is generally accomplished by equipping the circuit breakers so they can be tripped by reverse-current relays.

Advantages of Diagonal Over Head-to-Head Stays—What are the advantages of diagonal stays over head-to-head stays in a return-tubular boiler?

W. N. E.

The shell has sufficient strength to resist all the pressure on the areas of the heads required to be stayed above and below the tubes, and that strength can be utilized by the employment of diagonal stays with the advantage of occupying comparatively little space in the steam room, thus permitting easier inspection and cleaning than when through bolts are used; and diagonal stays being shorter than through stays, there is less effect from unequal expansion.

Noisy Exhaust Valves—When our 16 x 36-in. Corliss engine is lightly loaded, there is a slapping noise from the exhaust valves. How can the trouble be prevented?

T. N. B.

Undoubtedly, steam-engine indicator diagrams would show that when carrying the light load, the cutoff is very short with expansion carried to a pressure below the atmosphere. When this occurs, the exhaust valves are forced from their seats by pressure of the atmosphere causing a slapping or clattering noise, as when an engine is being shut down. The remedy is to throttle the steam, or lower the boiler pressure, and obtain cutoff so late in the stroke that the steam will not be expanded below atmospheric pressure.

Induction-Motor Rotor Connections—I have rewound the rotors of a number of wound-rotor-type induction motors and in each case the winding was connected star. Can the delta connection be used in grouping these windings? If so, why is it not used more generally?

M. T. R.

Either connection may be used, but in small and medium motors the star connection gives a more satisfactory winding design. The star connection gives a terminal voltage 73 per cent higher at the slip rings than the delta connection. This is very desirable where the rotor is bar wound, since with this type of winding the voltage is comparatively low, and the current relatively high value. With the star connection the current will be 58 per cent of that obtained with the delta connection. Consequently, the starting resistance is much cheaper to construct. In some large-sized motors, however, the voltage produced in the rotor winding with a star connection may be so high as to be difficult to insulate and also require specially designed central equipment to make them safe for an operator to handle. In such cases the rotor is connected delta, as this grouping generally gives a voltage at the slip rings that is of a safe value.

Pull and Power Required to Draw Car Up Incline—In a balanced monitor incline system it is required to raise a load of 7,500 lb. up an incline 750 ft. long, a total elevation of 150 ft. The speed of rope carrying the load is 600 ft. per min. There will be two cars, one being pulled up the incline loaded, while the other returns empty. Neglecting friction, air resistance and weight of cars, what will be the pull on the rope and what horsepower will be required?

A. F.

When the car is held at rest or is being drawn up the incline at a uniform speed, the pull on the rope would amount to $\frac{1}{5}\frac{5}{0}$ of 7,500 lb. = 1,500 lb., and while drawn up the incline at the uniform speed of 600 ft. per min., the power required would be $600 \times 1,500 \div 33,000 = 27.27$ hp. For moving the car up the incline from a state of rest, there would be an additional pull on the rope, depending on the acceleration. If the time allowed for increasing the speed from 0 to 600 ft. per min., or 10 ft. per sec., was 15 sec., with uniform acceleration, then the acceleration would be $10 \div 15 = \frac{2}{3}$ ft. per sec. Forces are to each other as the accelerations produced. The acceleration due to gravity is 32.16 ft. per sec., and therefore the force required to produce the acceleration only would be $7,500 \times \frac{2}{3} \div 32.16 = 155.4$ lb. and the whole pull on the rope while raising the speed of the car to 600 ft. per min. would be $1,500 + 155.4 = 1,655.4$ lb.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

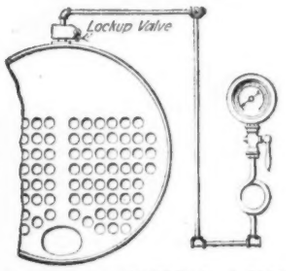
Interpretations of the A. S. M. E. Boiler Code

The following answers to requests for interpretations of the Boiler Code have been prepared by the Boiler Code Committee and approved by the Council of the American Society of Mechanical Engineers. The formal inquiry and reply are given together with explanatory references to the Code and illustrations where necessary for a better understanding of the interpretations as issued.

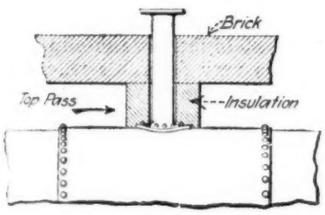
Case No. 273—Inquiry: Does Par. 296 of the Boiler Code require that the tee or lever-handled cock be placed immediately under the steam gage where a long connecting pipe is used and the locked open valve is permitted close to the boiler?

Par. 296 provides that the connection of the steam gage shall be so arranged that the gage cannot be shut off from the boiler except by a cock placed near the gage and provided with a tee or lever handle arranged to be parallel to the pipe in which it is located when the cock is open. When the use of a long pipe becomes necessary, an exception to this rule is provided so that a shutoff valve or cock may be used near the boiler if arranged so that it can be locked or sealed open.

Reply: It is the intent of the requirement in Par. 296 that the tee or lever-handled valve shall be located near to the steam gage so that it will be readily evident to anyone observing the gage, even though the locked-open valve is used at or near the boiler.



CASE 273—TYPICAL LONG PIPE CONNECTION TO GAGE



CASE 274—EXTENDED NOZZLE FOR USE WITH TOP PASS SETTING

Case No. 274—Inquiry: Is it permissible to use upon horizontal return tubular boilers with the top pass type of setting, extended nozzles formed of a short length of pipe screwed into flanged fittings at the boiler connection and the outer end, in order that it may reach well above the boiler brickwork?

Reply: The construction proposed will not meet the Code requirements, where the pipes are over 3 in. pipe size and the working pressure exceeds 100 lb. per sq.in. A double-flanged nozzle riveted to the boiler shell should be provided, and such a nozzle, when used, should be protected by insulation.

Case No. 276—Inquiry: In the design of a cast-steel water box to be set in the side walls of furnaces and to be subjected to full boiler pressure, is it necessary to apply to the sections containing flat surfaces, the formula in Par. 199 of the Boiler Code, using $C = 120$, or is it necessary to use this formula with the value of $C = 156$?

Reply: It is the opinion of the committee that the construction of pressure parts of the type referred to is provided for by Pars. 9 and 247. If the secretary of the Boiler Code Committee can be notified when the specimen is ready for test, steps will be taken to have a representative of the committee present.

Par. 9 provides for the use of wrought steel or cast steel of Class B grade as designated in the Specifications for Steel Castings for water boxes when the pressure exceeds 160 lb. per sq.in. Par. 247 provides that where it is impossible to calculate with reasonable accuracy the strength of any part of a boiler structure the manufacturer shall build a full-sized sample which shall be tested to destruction in the presence of the Boiler Code Committee or one or more of its representatives.

Case No. 277—Inquiry: (*a*) An interpretation is requested of the application of Par. 212*a* of the Boiler Code with reference to any curved stayed surface subject to internal pressure. Does this refer to both the outer and furnace sheets of vertical tubular boilers?

(*b*) If under the requirements of Par. 239 of the Boiler Code relative to furnaces under 36 in. in diameter, the design of the furnace does not permit of operation without staying, is there any rule in the Code for the staying in this case, or must the furnace sheets be stayed as flat surfaces, in accordance with Table 4 of maximum allowable pitch of screwed and riveted stay bolts?

Par. 212*a* provides for computing the working pressure of a curved stayed surface by making the proper deductions for the weakening effect of the staybolt holes. To this is to be added the pressure allowed for a flat stayed surface, computed both from the stiffness of the plate and from the strength of the stays, the minimum value being used.

(*c*) Is it the intent of Par. 212*c* of the Boiler Code that the increased pitch allowed, may be used for the same working pressure and thickness of plate as indicated in Table 4? It is the understanding that Table 4 is based on the formula given in Par. 199.

A formula for the allowable pressures on stayed surfaces based on the thickness of the plate and pitch of the stays is given in Par. 199, and values of the maximum allowable pitch of screwed stays for various pressures and plate thicknesses as computed by this formula are given in Table 4. Par. 212*c* provides for an increase in the allowable pitch for cylindrical furnaces over that indicated by Table 4, this increase to be determined by a formula based on the pressure, radius of the furnace and thickness of the plate.

Reply: (*a*) The term "curved stayed surface subjected to internal pressure" in Par. 212*a* of the Code is intended to refer to any surface in a boiler structure that is subjected to pressure on the concave side. It therefore refers only to that part of the outer shell of a vertical boiler which is stayed.

(*b*) Where a furnace under 36 in. in diameter requires staying, it should be stayed as a flat surface as provided for in Table 4, except that the pitch may be increased as indicated in Par. 212*c*.

(*c*) It is the intent of Par. 212*c* that the increased pitch there permitted, may be used for the same steam pressure and thickness of plate as specified in Table 4.

Case No. 279—Inquiry: Is it permissible under the requirements of the Boiler Code to construct steel heating boilers in diameters up to 72 and 78 in. with shell plates ¼ in. in thickness? Is it the opinion of the committee that boilers of the h.r.t. type so constructed have sufficient shell plate strength to permit of proper lug attachments for support of the shell?

Reply: The section of the code on Heating Boilers is incomplete in not specifying the minimum plate thickness to be used in the shells and tube sheets, and below which the thickness shall not be made in any case. The Boiler Code Committee recommends that until a revision be made to cover this class of boiler construction, the minimum thickness of shells and heads for various shell diameters of steel plate heating boilers, shall be as follows:

Diameter of Shell, Tube Sheet or Head.	Minimum Thickness Allowable under Rules	
	Shell, in.	Tube Sheet or Head, in.
42 in. or under	1/4	5/16
Over 42 in. to 60 in.	5/16	3/8
Over 60 in. to 78 in.	3/8	7/16
Over 78 in.	7/16	1/2

Case No. 280—Inquiry: (*a*) Is it permissbile under the requirements of the Boiler Code to use a blowoff valve of the type used on locomotive boilers, operated by a lever lift, for stationary boilers?

(*b*) Is it considered safe to use superheated steam of 125 lb. pressure and 125 deg. of superheat, or total nominal temperature of 478 deg., with a piping system having extra-heavy cast-iron fittings and medium-weight cast-iron valves?

Reply: (*a*) It is the opinion of the committee that the blow-off valves required by Par. 311 for stationary boilers, may be of the lever-lift type, provided they are of extra-heavy construction, and so designed that they may be operated without shock to the boiler.

Par. 311 provides that all boilers, except those used for traction or portable purposes, when the maximum allowable working pressure exceeds 125 lb. per sq.in., each bottom blowoff pipe shall have two valves or a valve and a cock, both of which shall be extra-heavy.

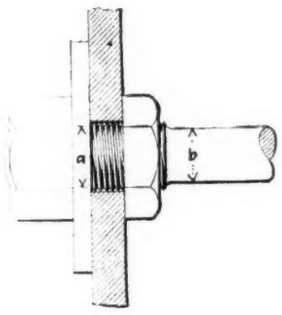
(*b*) Attention is called to Par. 12 of the Code, which states that "cast iron shall not be used for nozzles or flanges attached directly to the boiler for any pressure or temperature, nor for boiler and superheater mountings such as connecting pipes, fittings, valves and their bonnets, for steam temperatures of over 450 deg. F." While the Code only covers the parts therein specifically mentioned, this paragraph clearly indicates the judgment of the committee as to the safety of the construction in question.

Case No. 281—Inquiry: Is it the intent of Par. 306 of the Boiler Code that every superheater shall be so fitted with a drain that it can actually be completely drained? Many superheaters are fitted with drains which are, however, unable, on account of their positions, to completely drain the apparatus.

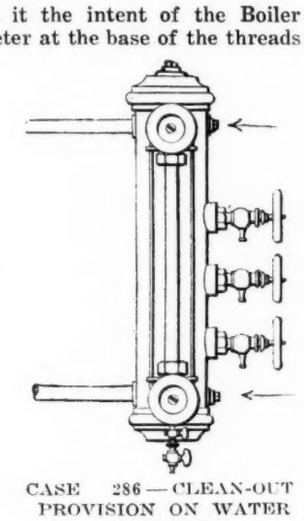
Par. 306—Each superheater shall be fitted with a drain.

Reply: It is the opinion of the committee that every superheater should be so fitted with a drain as to substantially free the superheater from water when the drain is opened.

Case No. 282—Inquiry: Is it the intent of the Boiler Code Committee that the diameter at the base of the threads



CASE 282—IT IS DESIRABLE THAT *a* BE GREATER THAN *b*



CASE 286—CLEAN-OUT PROVISION ON WATER COLUMN

on the threaded ends of through rods or braces for h.r.t. boilers, shall be equal to or greater than the nominal diameter of the rod? Fig. 14 and Pars. 208 and 211 would seem to infer that it should be at least equal, but isn't it preferable to make it greater, so that the point of greatest weakness in the rod may not be in the threaded portion where permanent set due to strain would tend toward fracture?

Reply: It is the opinion of the committee that it will be desirable that the threaded ends of through rods or braces for h.r.t. boilers, shall be sufficiently upset so that the minimum diameter at the base of the threads is in excess of the nominal diameter of the rod.

Case No. 284—Inquiry: Is it the intent of Pars. 269 and 270 of the Boiler Code that a boiler requiring safety-valve relieving capacity greater than 2,000 lb. per hour shall have two safety valves, each one of which alone will properly discharge the steam, or does it require two safety valves, the combined capacity of which will properly discharge the steam?

Par. 269 provides that each boiler shall have two or more safety valves, except a boiler for which one safety valve having a relieving capacity of 2,000 lb. per hour or less, is required.

Par. 270 provides that the safety-valve capacity for each boiler shall be sufficient to discharge all the steam that can be generated by the boiler without a rise in pressure of more than 6 per cent above the maximum allowable working pressure or more than 6 per cent above the highest pressure to which any valve is set.

Reply: For capacities greater than 2,000 lb. per hour, the Code requires two or more safety valves on each boiler, the combined capacity of which shall meet the requirements of Par. 270.

Case No. 285—Inquiry: Is it permissible under the rules of the Boiler Code to use standard extra-heavy cast-iron flanges and fittings on pipe connections between boilers and attached-type superheaters, and on the ends of superheater-inlet headers for pressures up to 250 lb. per sq.in.? It is pointed out that neither the inlet-pipe connections nor the superheater-inlet flanges would be subjected to other than saturated steam temperatures.

Reply: It is the opinion of the committee that the flanges referred to may be made of cast iron, provided the temperature of the steam does not exceed 450 deg. F., as specified in Par. 12.

Case No. 286—Inquiry: Does Par. 321 of the Boiler Code require that all water-column connections to boilers must be fitted with crosses for cleanout purposes, or is it permissible in a connection of a water column to a steam drum to omit the crosses, provided provision for cleanout is afforded by the gage-glass connection on the opposite side of the water column?

Par. 321 provides that the water connections to the water column of a boiler shall be provided with a cross to facilitate cleaning.

Reply: It is the intent of Par. 321 that a cross be applied at a right-angle turn in the water connection to a column for purposes of cleaning. Where an easily accessible straight pipe connection is used without a turn, the cross is obviously not needed.

Case No. 289 (Revision of Case No. 254)—Inquiry: Does the reply to Case No. 254 apply only to flat plates or also to the holes in the shells of drums?

The reply in case No. 254 provided that burning might be substituted for punching and shearing of rivet holes and plate edges, provided the holes were burned $\frac{1}{8}$ in. less diameter than the finished hole and that the burned surfaces of caulking edges be planed, milled or chipped for a depth of not less than $\frac{1}{4}$ in.

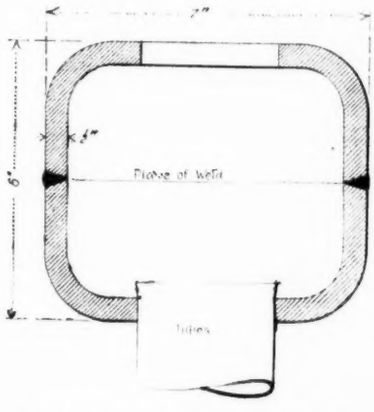
Reply: This case applies to flat sheets. It is not permissible to burn tube or other holes into the shells of drums unless such holes are strengthened with flange or other reinforcements.

Case No. 290—Inquiry: In determining the ratios of lengths between supports to diameter per Table 5, page 59 of the code giving "Maximum Allowable Stress for Stays and Staybolts," is the diameter at the root of the thread to be used, or the diameter of the body of the stay?

Reply: It is the opinion of the committee that the diameter of the body of the stay is to be used in determining this ratio.

Communication

An inquiry was received relative to the permissibility of forming individual or sectional headers of *pressed channel-shaped sections*, welded together at the edges to form rec-



PROPOSED FORM OF WELDED HEADER NOT APPROVED

tangular-shaped headers. It was stated that the minimum thickness of metal was $\frac{1}{2}$ in., and the maximum cross-section 6 in. in depth by 7 in. in width, and it was pointed out that the United States Steamboat Inspection Service approves this construction when the two halves of steel plate are electrically welded, no staybolts being required.

The Boiler Code Committee decided that this construction does not conform to the requirements of the Boiler

Code and directed especial attention to Par. 186, which stipulates that "autogenous welding may be used in boilers in cases where the strain is carried by other construction which conforms to the requirements of the code and where the safety of the structure is not dependent upon the strength of the weld."

Water-Power Development in the United States*

Taking the eleven Far Western States, we find by careful survey an unusual situation. Due to delay of the construction program in power development while the nation was at war, this section of the country (the Pacific Coast) finds itself today facing a serious situation, ranging from an actual shortage of power to meet demands, as in California, to an impending shortage to meet growing demands in Oregon and Washington. With increasing possibilities of coal shortage, the continual rise of the price of oil and the economic desirability for early electrification of steam railroads, the urge for increased water-power development in the Far West becomes imperative. Not only are industries already existing dependent upon electrical development, but it is believed that industrial growth on the Pacific Coast and electrical development are interdependent. This is true in agriculture as well as industry. Vast areas of arid and semi-arid Western lands have been converted into fertile districts under electrical pumping of water that would be impossible without its use.

Federal legislation governing the use of public lands and reservations is of primary importance to the Western States, in which lie nearly all the public lands and in which approximately 70 per cent of the undeveloped water power of the nation is found.

Statistics of Potential Water Powers and Importance of Those Under Federal Control

The report discusses present and potential water powers of the United States from a statistical standpoint. The latest authentic estimate shows that there are approximately 59,360,000 hp. of potential undeveloped water power in the United States and only 9,823,540 hp. of developed water power. Of the potential maximum horsepower of the United States 68.6 per cent lies in California, Oregon, Washington, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming. Of the total maximum potential water power of the United States 74.3 per cent represents undeveloped horsepower coming under Federal jurisdiction, that is, lying on Federal reserve lands or on navigable streams wherein Federal permits are required. In the Western States 94 per cent of the maximum potential water power is in this class. In other words, practically all of the future development of water power in the Western States, covering approximately 70 per cent of the total potential water power of the country, will be dependent upon Federal action in the matter of issuance of workable permits for the development of these projects. Also it is of considerable note that only 16.6 per cent of the maximum potential water power has been developed up to the present time. For the Western States this proportion is only 6.5 per cent.

In the case of the Central and Eastern States, particularly New England, it is shown that a comparatively large portion of the potential water power has been already developed. In the case of the New England States the high percentage of 77.2 per cent already developed shows that little additional water-power development is to be expected in this district.

While compared with the potential possibilities, the development in the Western States has been comparatively small, attention is directed to the present development of water power in these Western States. For instance, California is shown well in the lead with a present development of 942,000 hp., which is 10 per cent of the entire developed water horsepower of the United States. It is, however, only 10.2 per cent of the maximum potential water power possibilities of that State. Washington shows the largest maximum potential water horsepower of any state in the Union, but it ranks among the Western States below both California and Montana in the amount of developed water horsepower, showing a development of but 3.8 per cent of its potential maximum possibilities and only 3.7 per cent of the total developed water horsepower of the country. Oregon also shows wonderful potential waterpower possibilities, but up to the present time only a very low percentage is developed, 3.5 per cent of the maximum possibilities of the state. These figures clearly show that although the West has already developed some remarkable waterpower projects and is well up in the lead of the development of large interconnecting networks of transmission systems, the water-power development in this section is but begun.

Discussion of Power Consumption by the United States Compared With That in the West

A table is shown giving population, kilowatt-hours, consumption, gross revenue, kilowatt-hours per capita, cost per kilowatt-hour, revenue per capita. The total for the United States shows a population of 109,843,000. The consumption in millions of kilowatt-hours is 36,734.7. The gross revenue in millions of dollars is 773. The kilowatt-hours per capita is 334. The cost per kilowatt-hour is $0.0212. The revenue per capita is $7.05. The figures given by districts show that the per capita use of electricity in the Far Western States is 2.21 times that of the remainder of the nation. Here again it is interesting to note that, while distances are vast, the development of long-distance hydroelectric transmission has made possible electric-power rates that are extremely low, averaging 1.655 per kilowatt-hour as compared with 2.19c. obtained elsewhere in the country.

In potential water power, the State of Washington stands first, with 9,500,000 hp., or 16 per cent of the total potential water power of the United States. California is a close second, with 9,250,000 hp., or 15.6 per cent of the total United States. Oregon ranks third, with 7,100,000 potential hp. The coast states together represent 43.6 per cent of the total potential maximum horsepower of the United States. Including Idaho and Montana, these five typically Western States represent 61 per cent of the total potential maximum water power of the United States with a total of 36,210,000 horsepower.

Reference Made to Contemplated Developments in Eastern States

Over 1,000,000 hp. is contemplated in the states of Alabama, North Carolina, Georgia and Maryland.

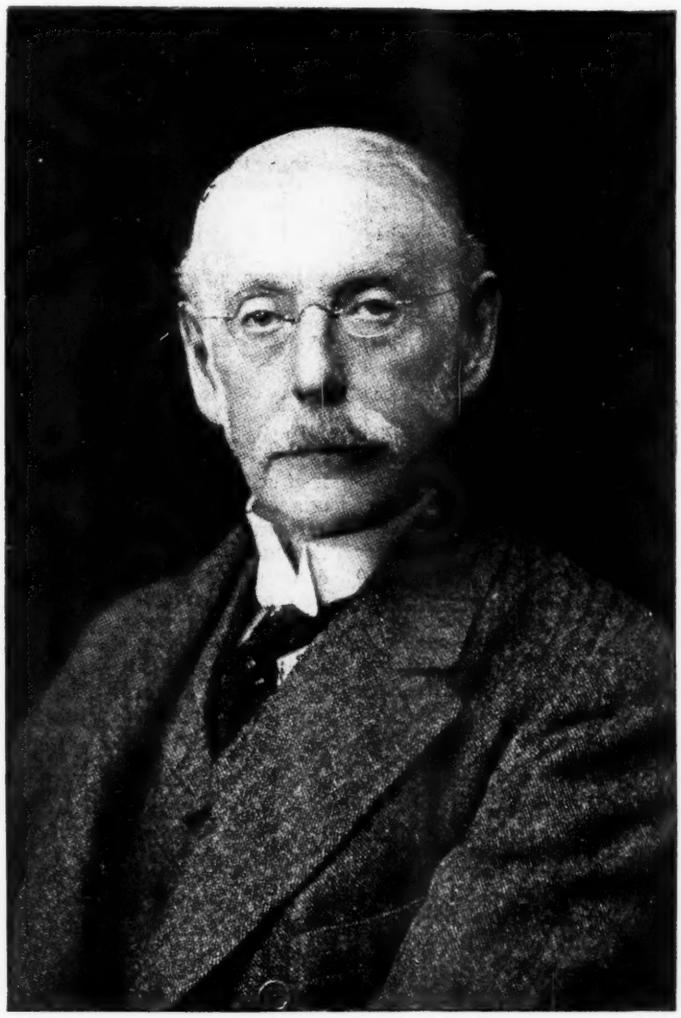
Data obtained from 52 power companies of the Far Western States, showing their loads during the past ten years and also their estimated loads up to and including 1928, has been obtained and compiled and presented in the report in connection with graphic charts. They show that during the next ten years the expected development of power in the West will rise to the vast total of 1,776,260 kw., which, at present-day prices for material and labor, will involve an investment of over $700,000,000.

The importance of conservation of fuel oil in the Western States is emphasized in that the Pacific-Coast supply of fuel oil and of petroleum is rapidly approaching exhaustion. Since May 1, 1915, crude-oil stocks in California have decreased from over 60,000,000 bbl. to 28,738,921 bbl. on March 1, 1920. The available supply of crude oil in stock today is less than 13,000,000 bbl. At the present rate of consumption and of production the available stock will be exhausted in about twelve months, at which time consumers of California fuel oil will be cut off from between 25,000 to 30,000 bbl. per day. In California during the year 1918-19 there were two sets of interconnected networks in the state, one in the northern the other in the southern portion. The control of each system was under the management of a power supervisor. As a result of this arrangement there was effected a saving of 300,000 bbl. of oil in 1919, representing $450,000.

*Abstract from the report of the N.E.L.A. Committee on Water-Power Development, presented before the forty-third convention, held at Pasadena, Cal., May 18-22, 1920, by Franklin T. Griffith, chairman of the committee, and president of the Portland Railway, Light & Power Company.

Sir Charles A. Parsons, K.C.B.

Perfecter of the Reaction Steam Turbine, Receives the Franklin Medal



THE eminent British engineer and scientist, Sir Charles A. Parsons, perfecter of the reaction steam turbine, has been honored by America, receiving the Franklin Medal. The other recipient also is a European, Svante Arrhenius, of Sweden.

Sir Charles Parsons was born June 13, 1854, as the fourth son of the third Earl of Rosse, who was a president of the Royal Society, and built that famous telescope which is still the largest instrument of its kind.

The son received his early education entirely by private tuition, and later attended Dublin University and Cambridge. At that time (about 1877) he made models of his epicycloidal engine, and while serving a four years' apprenticeship in the Elswick Works of Sir William Armstrong he constructed the first engine of this type. It was a four-cylinder revolving engine in which the cylinders rotated around the revolving crankshaft.

Mr. Parsons then turned his attention to the development of the steam turbine. He conceived the idea of splitting up the fall in pressure over a great number of turbines in series, that the aggregate of these simple turbines, constituting a complete machine, would give an efficiency approximating that of water turbines. In 1884 he patented his first steam turbine. This, of 10 hp., at 18,000 r.p.m., was used for driving a high-speed dynamo. It marked the beginning of turbo-generator development for electric drive. During the next five years he constructed many improved forms of turbo-dynamos. In 1889 he organized the works at Heaton.

The first compound turbine was built in 1887 and the first condensing turbine in 1892, when there was at once a great advance in efficiency, the steam consumption being reduced from 55 lb. to 27 lb. per kw.-hr. In 1895 the steam turbine was first applied to marine work, and two years later the experimental steamer "Turbinia," driven entirely by turbines, was completed. She had a length of 100 ft., 9 ft. beam, 44 tons displacement; speed attained on her trial trip, 34 knots. In 1905 the "Amethyst," driven by turbines, beat her sister ship, the "Topaz," driven by reciprocating engines. From this time on the construction of turbine-driven vessels advanced by leaps and bounds, until the present time, when the turbine has not only completely supplanted the reciprocating engine in war vessels, but to a great extent also, either wholly or partly, in the great ocean liners and mercantile steamers. By connecting the turbines to the propeller by gearing, he has made possible another great stride in turbine propulsion.

Sir Charles Parsons has made valuable contributions and inventions along other lines in physical science, among them improvements in gramophones and investigations on the formation of diamonds.

Sir Auckland Geddes, British Ambassador, received the Franklin Medal for Sir Charles.

The Flow of Air Through Small Brass Tubes*

By T. S. Taylor

The investigations discussed in this paper were undertaken as a preliminary study of the general ventilation problem, dealing in particular with the flow of air through tubes of various sizes and shapes. Information was sought as to the variations in the velocity of air at different points in the cross-section of the tube and at different distances from the fan. The effect of dirt on the inside walls of the tubes was also investigated.

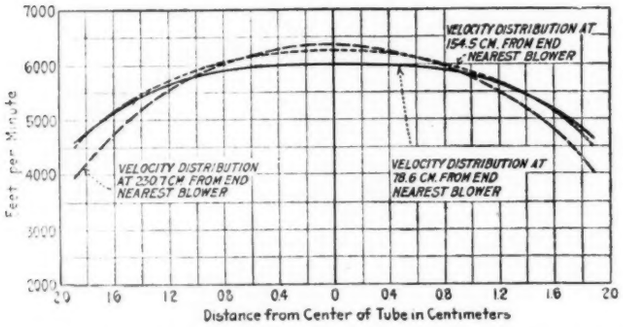

VELOCITY DISTRIBUTION AT 154.5 CM. FROM END NEAREST BLOWER
VELOCITY DISTRIBUTION AT 230.7 CM. FROM END NEAREST BLOWER
VELOCITY DISTRIBUTION AT 78.6 CM. FROM END NEAREST BLOWER
Feet per Minute
Distance from Center of Tube in Centimeters

FIG. 1. VELOCITY DISTRIBUTION AT THREE POINTS IN A 1½-IN. TUBE 8 FT. LONG

The tubes thus far tested were of seamless brass having internal diameters of ⅝ in., ¾ in. and 1½ in., respectively. Velocity measurements were made by means of pilot tubes, those for preliminary study being $\frac{3}{64}$ in. external diameter and those for study of the velocity distribution being about $\frac{1}{16}$ in. external diameter. Velocity pressures were measured by means of inclined oil gages, and the velocity calculated by the usual formula,

$$V = \sqrt{\frac{2\,g\,h\,d}{d'}}$$

in which

V = Velocity of air in feet per second;
g = Acceleration due to gravity;
h = Difference in level in the gage;
d = Density of the liquid in the gage;
d' = Density of the air.

The air current was furnished by a No. 3V blower made by the American Blower Co., and driven by a direct-current motor that could be run so as to give any desired speed to the blower. To prevent vibration being transmitted to the tube from the motor and blower, a short rubber hose connected the blower and the tube under test.

A study of the velocity distribution at various positions along a 1½-in. tube 243.6 cm. (8 ft.) long was made, and the curves in Fig. 1 show this distribution at three points, 78.6 cm. (31 in.), 154.5 cm. (61 in.) and 230.7 cm. (91 in.) from the end nearest the blower. The velocity at the center of the tubes is seen to increase as the distance from the blower increases, being 6,000, 6,200 and 6,270 ft. per min. at the first, second and third points shown, respectively.

The average velocity at a given cross-section in the tube, obtained by multiplying the velocity in each concentric zone by the area of the zone and dividing the sum of these products by the cross-sectional area of the tube, was found to be the same, 5,300 ft. per min., for all cases. These results show that the velocity distribution of air flowing through tubes does not reach a steady state at ten times its diameter from the entrance as is usually assumed. To obtain further information on this point, a second tube 407 cm. (about 13.3 ft.) long and 1½ in. in diameter was used. It was found that the velocity distribution was the same for all points more than 200 cm. (about 79 in.) from the blower end of the tube.

Another interesting point was that the ratio of average velocity to maximum velocity for various velocities was practically constant with a general mean value of 0.84. The velocity measurements used in determining these values were taken at a point 240 cm. (about 95 in.) from the blower end of the 1½-in. tube. Similar observations were made on the smaller tubes, which resulted in a general mean of 0.830 in. in the ¾-in. tube and 0.870 in the ⅝-in.

TABLE I. COMPARISON OF VELOCITY RATIOS IN CLEAN AND DIRTY TUBES.

Dia. of Tube In.	Clean Tube: Ratio of Average to Maximum Velocity	Dirty Tube: Ratio of Average to Maximum Velocity	Approximate Thickness of Dirt Film, In.
1½	0.832	0.749	0.006
¾	0.833	0.648	0.016
⅝	0.825	0.795	0.008

TABLE II. STATIC PRESSURE IN INCHES OF WATER TO MAINTAIN AN AVERAGE VELOCITY OF 3,000 FT. PER MIN. IN TUBE 5 FT. LONG.

Dia. of Tube In.	Clean Tube	Dirty Tube
1½	0.37	0.94
¾	0.80	3.20
⅝	1.00	5.00

tube for this ratio. These results indicate that the velocity distribution for steady state, across smooth brass tubes, is practically the same for all the tubes and for all average velocities from 0 to 6,000 ft. per minute.

Having obtained the foregoing data on the air flow through smooth tubes, oil was poured through tubes of 1½, ¾ and ⅝ in. diameter, each being a little over 5 ft. long. Coal dust was then sifted through the tube and only that allowed to remain which was not readily jarred out. After measurements were taken, the oil and dust were wiped out of the tubes and the thickness of the layer was determined from its mass and density. The value of the thickness thus determined is only approximate as the dirt is not uniformly distributed, but gathers in small clusters. The velocity across each tube was measured for various air velocities and the results obtained summarized in Table I.

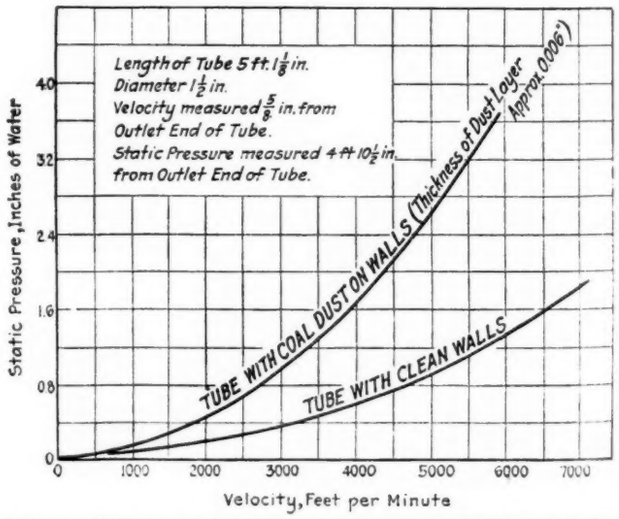

Length of Tube 5 ft. 1⅛ in.
Diameter 1½ in.
Velocity measured ⅝ in. from Outlet End of Tube.
Static Pressure measured 4 ft. 10½ in. from Outlet End of Tube.
TUBE WITH COAL DUST ON WALLS (Thickness of Dust Layer Approx. 0.006")
TUBE WITH CLEAN WALLS
Static Pressure, Inches of Water
Velocity, Feet per Minute

FIG. 2. EFFECT OF DUST ON STATIC PRESSURE NECESSARY TO FORCE AIR THROUGH 1½-IN. TUBE

The static pressure necessary to force air through the 1½-in. tube at various velocities was measured for the clean and dirty tubes, and the results are plotted in Fig. 2. A study of these curves and of Table I indicates that a very small but irregular distribution of dirt will have a decided effect upon the amount of air that will pass through the tube. The effect is not due merely to a diminution of area, but also to turbulency due to the presence of the dust. Table II shows the values of static pressure necessary to force air at 3,000 ft. per min. through clean and dirty tubes.

*From a paper presented at the Spring Meeting, St. Louis, May, 1920, of the American Society of Mechanical Engineers.

Coal Industry Profits

Charges and countercharges as to the profits being made in the coal industry, along with rumors of a pending return of price control and of the re-establishment of the coal zones, recently made Washington the center of interest in the coal situation. Senator Walsh of Massachusetts, in the course of a speech on the floor of the Senate, accused coal operators of having made enormous profits. His position was backed up by Senator Kenyon of Iowa. Senator Smoot of Utah attacked that portion of Senator Walsh's charges which were based upon a report as to coal profits that had been submitted by W. G. McAdoo while he was Secretary of the Treasury. Senator Smoot pointed out that many of the deductions as to profits which were made in that report were unfair. The discussion of the matter of coal operators' profits on the floor of the Senate led J. D. A. Morrow, the vice-president of the National Coal Association, to issue a formal statement going extensively into the matter of coal operators' profits. He used in his calculation the figures furnished by the Bureau of Internal Revenue to the President's Bituminous Coal Commission to show that profits, which averaged less than 11 per cent, were justified in a business so hazardous as the mining of bituminous coal.

In addition W. Jett Lauck appeared before the Railroad Labor Board and made charges to the effect that wholesale profiteering is taking place in the coal industry. In that connection, however, it may be pointed out that the statistics of the Federal Trade Commission, which are being fought so strenuously by the coal operators, are just at this time standing them in good stead. Despite the fact that an injunction has been granted restraining the Federal Trade Commission from demanding cost sheets from coal operators, most operators continue to file their costs with the commission, from which certain generalizations are made public. The returns for February show that the average margin per ton throughout the United States was only 31c. This does not represent profit, as selling expense, interest on investment and Federal taxes still must be deducted. In the Central Competitive Coal Fields the average margin per ton was 28c.

With the Interstate Commerce Commission's action in an effort to relieve the traffic congestion came the word that price control is to be restored and the coal zones re-established. No credence is given either of the rumors by those in close touch with the situation. So far as re-establishing the zones is concerned, it is believed that an injunction could be secured which would prevent such an order going into effect, even if it were attempted.

Analysis of the Central Electric Station Industry in Canada

The Dominion Water-Power Branch, Department of the Interior, in co-operation with the Dominion Bureau of Statistics, is publishing an analysis of the results of the second census of central electric stations in Canada, showing the status at Jan. 1, 1919. The report includes statistics relative to central electric stations only, as defined for census purposes; that is, stations that sell or distribute electrical energy for lighting, heating or general power purposes, other than that generated by industrial organizations for their own direct use in the operation of some other industry.

The principal items reported, together with a comparison between the totals for commercial or privately owned and municipal or publicly owned stations, are summarized in a table. The total number of stations reporting is 795, of which 515, or 64.8 per cent, generate their own power, and 280, or 35.2 per cent, are of the non-generating type. The commercial stations numbered 377, and the municipal stations 418. Of the generating stations 332 are commercial and 183 municipal, while of the non-generating stations 45 are commercial and 235 municipal.

The aggregate capacity of all primary power machines reported is 1,958,642 hp., of which 1,841,114 hp. is installed in main plants and 117,528 hp. in auxiliary or stand-by plants. Of the total for the main plants 1,434,196 hp., or 77.9 per cent, was reported by commercial stations, and 406,918 hp., or 22.1 per cent, by municipal stations, while of the auxiliary plant equipment the former accounted for 110,853 hp. and the latter 6,675 hp. The figures are also given separately for main plants and for auxiliary or stand-by plants. According to source of power the total for all prime movers is divided as follows: From water, 1,682,191 hp.; from steam, 262,562 hp.; from gas and fuel oil, 13,889 horsepower.

The average primary power installation of the main plants per thousand population for the Dominion is 209 horsepower. Of the aggregate capacity of all prime movers installed in the main plants, 1,682,191 hp., or 91.4 per cent, is derived from water, and including the prime movers of auxiliary or stand-by fuel plants the hydraulic installation represents 85.0 per cent of the total. Saskatchewan derives 100 per cent of its central-station energy from fuel.

For the Dominion the total capital invested in the industry was reported as $401,942,402, of which $356,547,217 represents the investment in power development and transmission and distribution systems and $45,395,185 represents miscellaneous supplies and working capital. The commercial stations reported 71.7 per cent of the total capital and the municipal station 28.3 per cent.

For the Dominion the total capital invested in hydro-electric stations is $364,479,961, representing a total investment of $218 per installed turbine horsepower and accounting for 90.7 per cent of the total capital invested in all central electric stations in Canada. As this capital includes investments in fuel power plants, which are operated as auxiliaries to hydro-plants, the capacity of the primary power machines of these plants added to the capacity of the hydraulic turbines gives a more logical basis for this analysis and, reduces the capital investment per installed primary horsepower for the hydro-stations to $203. In connection with enlargements of existing plants the hydro generating stations reported new installations contemplated for the immediate future amounting to 135,755 horsepower. The ultimate designed capacity of existing hydro-electric central stations is 2,115,043 horsepower.

Technical Advisory Committee To Continue Work

The Technical Advisory Committee, who were chiefly instrumental in the settling of more than $3,000,000,000 worth of war contract claims for the War Claims Board, have decided to offer their services to the industries of this country and have opened headquarters at 132 Nassau St., New York City.

In the course of their war claims work they touched every branch of American industry, as the claims ran from small ammunition to the greatest power developments ever made.

Members of the Technical Advisory Committee who have completed their war contract work and are engaged in strictly peace work are: Campbell Scott, New York, president of the new corporation, who is an industrial executive and manufacturing specialist; Ernest P. Goodrich, of New York, vice-president and treasurer, a specialist in waterways and the designer of the Bush Terminal; William D. Ennis, of New York, vice-president and secretary, specialist in fuel, power and manufacturing; Col. Frank B. Maltby, of Philadelphia, who built the railways, docks, terminals and warehouses of St. Nazaire, France, for the A. E. F. and was formerly chief assistant engineer of the Panama Canal; Walter Rautenstrauch, of New York, a specialist in manufacture of machinery and steel products; George B. Frankforter, of Minneapolis, chemical specialist and dye expert; Arthur W. Hixson, of New York, specialist on fuels, heavy chemicals, plant design and general manufacturing; Fred E. Rodgers, of New York, expert machinery designer; and Rumsey W. Scott, of New York, who has had long experience in industrial transportation and the handling of equipment. All will continue to serve the Government in an advisory capacity and will go to Washington whenever needed.

Havana Central Station to Double Power-Plant Capacity

On account of a rapid increase of load and the possibility of a still further growth in the next few years, the Havana (Cuba) Electric Railway, Light and Power Co. has ordered two 25,000-kw. Westinghouse steam turbine-generators to double its plant rating. At present there are, in this plant, three 12,500-kw. generators supplying a combined railway and power load. In the original installation space had been provided for only one additional unit, but now that the load has become so great it was thought necessary to increase the capacity still more. Consequently, the two 25,000-kw. units were ordered, one to be installed in the space available, and the other to replace one of the 12,500-kw. units. By this means it is unnecessary to extend the power-plant buildings. However, the 12,500-kw. unit is in excellent operating condition and will probably be utilized elsewhere.

The first unit will be installed and will be in operation in 1921 and the second one will be on the line in 1922. They are to be designed to operate at 185 lb. pressure, 150 deg. superheat and a 28-in. vacuum. In addition, arrangements have been made to operate this equipment at higher pressures and superheats if desired at a later time. To go with these turbine-generators, Le Blanc 56,000-sq.ft. surface condensers and Le Blanc air and circulating-water pumps have also been ordered. Each condenser will have two circulating pumps and divided water boxes, so that one-half of the condenser may be cleaned while the other half is in operation.

This station, which is the largest in Cuba, is modern in every respect and has an operating economy comparable with that of some of the best plants in the United States. The average fuel consumption is less than two pounds of coal per kilowatt-hour, notwithstanding that the plant has a low load factor. This economy is due to the excellent operation and maintenance afforded by the management and operating engineers of the plant.

Convention of the American Order of Steam Engineers

The thirty-fourth annual convention of the American Order of Steam Engineers was held at Baltimore, Md., during the week beginning Monday, June 7, with headquarters at the Stafford Hotel.

There were seventy delegates in attendance, representing the various local councils of the association. The several sessions of the Engineers were held in Lehmann Hall, in close proximity to the headquarters; for this convenience, the local committee of arrangements is to be congratulated. Many important resolutions were brought before the body for discussion, and harmony was the prevailing keynote throughout the meetings of the delegates in their deliberations.

The main hall of the building, which immediately adjoined the meeting room of the delegates, was tastefully decorated and arranged for the American Supplymen's Association for the display of power-plant machinery and equipment.

The exhibition was officially opened on Monday evening at eight o'clock. Porter C. Jones, of the Dearborn Chemical Co., president of the Supplymen's Association, officiated, and in an appreciated speech told of the aims and objects of the American Order of Steam Engineers and the close friendship that has always existed between that organization and supplymen. Mr. Jones then introduced A. S. Goldsborough, director of the civic and industrial bureau of the Merchants and Manufacturers Association of Baltimore, who cordially welcomed the convention to the city. He spoke of the beauties of Baltimore and its great number of industrial and manufacturing plants and invited the visitors to inspect some of them. He dwelt on the increase of the merchant marine service of the city, which has risen from twenty-three steamship lines two years ago to more than fifty lines at the present time sailing to all ports of the globe. Mr. Goldsborough closed by inviting the convention to visit the offices of his association. W. Scott Price, president of the American Order of Steam Engineers, then declared the exhibit hall officially opened.

On Tuesday evening, at the exhibition hall, an enjoyable vaudeville performance was given under the auspices of the supplymen.

On Wednesday afternoon special cars were boarded for a crab feast at Liberty Park. The event was made pleasant by a baseball game and other outdoor sports and dancing.

On Thursday afternoon, by invitation of the American Order of Steam Engineers, a large number of the wounded soldiers, who are being trained in engineering and mechanics at the Maryland Institute under the direction of the Federal Vocational Commission, visited the exhibition. After inspecting the display they entered the meeting hall of the Engineers, where they were warmly welcomed and entertained.

On Thursday evening at nine o'clock there was an entertainment by home talent in the exhibition hall.

At the closing session the following supreme officers were elected for the ensuing year: W. Scott Price, chief engineer; George T. Crum, first assistant engineer; Harry J. Dunn, recording engineer; W. S. Wetzler, corresponding engineer; W. R. Smith, treasurer; Thomas H. Higgins, senior master mechanic; Harry Oler, junior master mechanic; William Stahler, outside sentinel; John Crean, inside sentinel; N. J. Feely, chaplain; George W. Goodwin, trustee.

The election of the officers of the American Supplymen's Association resulted as follows: William Lindenfelser, Jr., Texas Co., president; Roy C. Downs, Lord's Boiler Compound, vice president; Andrew Lauterbach, Lunkenheimer Co., secretary; John W. Armour, *Power*, treasurer; Maurice L. Willets, Joseph Dixon Crucible Co., director of exhibits.

Convention of the New York State Association N. A. S. E.

The twenty-fifth annual convention of the New York State Association of the National Association of Stationary Engineers was held at Niagara Falls, on Friday and Saturday, June 11 and 12, with headquarters at the Temperance House.

Chairman Robert Craig and his committee are to be congratulated upon the excellence of the arrangements. The large lobby was suitably decorated for the use of the supply men in the display of their various supplies for the engine room and power plant. In the large tea room, immediately adjoining, the meetings of the delegates were held. Forty engineering supply firms occupied booths, and much interest was shown in the exhibit.

At the opening session of the delegates the Credential Committee reported that there were 54 delegates present. Several important measures were brought before the body, and great interest was shown by the delegates in every discussion. It was decided to start a big drive immediately to boost the membership of the N. A. S. E. in New York State, and for this purpose an Eastern and a Western propaganda committee were appointed and a fund was set aside to cover the expenses of this campaign. The business of the convention was conducted with harmony and dispatch. The treasurer's report places the organization in a sound financial condition.

The opening ceremonies took place on Friday morning. Robert Craig, chairman of the local committee, presided and introduced Rev. C. W. Walker, who gave the invocation. Maxwell M. Thompson, Mayor of Niagara Falls, cordially welcomed the delegates and guests. He expressed the desire that their visit be profitable and pleasurable, and the hope that they would come again in the near future. Past National President William J. Reynolds responded in a fitting manner to the hearty welcome of the Mayor. The gavel was then passed over to State President Robert Tobin, who appointed the necessary committees, after which the meeting adjourned until the afternoon session.

During the two days there were auto sightseeing drives for the ladies to places of interest in the city. On Friday afternoon the delegates inspected the hydro-electric plants. On Friday evening there was a banquet at which covers

were laid for 150 delegates and guests. Past National President Royal D. Tomlinson acted as toastmaster. Short addresses were made by Robert Tobin, W. J. Reynolds, Robert Craig, J. N. Gregory and John J. Reddy. The entertainment was furnished by Billy McKay, Frank Howard, William Eagan, Dearborn Chemical Co.; Bob Jones, France Packing Co.; and Jack Armour, *Power*.

At the Saturday afternoon session the following state officers were elected: Robert Tobin, past president; Arthur E. Dowd, president; S. Hackaberry, vice president; William Roberts, secretary; William Downes, treasurer; Herbert E. Hall, conductor; Charles F. Eider, doorkeeper; Edward Lee, chaplain; Warren E. Lewis, state deputy. The propaganda committee for the Eastern District comprised P. J. Cassidy, William W. Downey and John McInnis. The Western District propaganda committee included H. G. Patrick, George Sterling and Charles F. Eider. P. J. Cassidy, George Van Vechten and Robert Craig were appointed on the License Law Committee. W. J. Reynolds was the installing officer.

In the evening an interesting and instructive illustrated lecture was given by C. C. Trump, of the Fuller Engineering Co., on "The Operating Merits of Pulverized Coal." Following the lecture a number of slides were shown of the Falls and rapids, dating back from 1871 to the present time.

Retiring State President Robert Tobin was presented a handsome mahogany clock, and a silver service was given to Mrs. Robert Tobin, the gifts of the Engineers and Supplymen.

New York was selected as the next convention city.

Fire Hazard in Transformers*

In considering the hazard of oil-immersed and of air-blast transformers, the number of units of each type involved must not be overlooked, or false conclusions will be drawn. In sizes of about 200 kva. there are probably at least 100 oil-insulated transformers installed to each air blast.

In the installation of air-blast transformers, generally one or more banks—that is, units of three single-phase or one three-phase transformer—are installed, ventilated by a single blower. In case of fire in any unit, either the blower must be shut down and the other units jeopardized, if their operation is continued, or the blower continues to operate and the defective transformer burns itself out unless extinguished by some special means. Probably not more than a dozen fires have occurred in air-blast transformers, and all of these in older types, and seldom has the fire been communicated to other apparatus.

Transformer construction of the oil-immersed type, as furnished by the various manufacturers in the earlier years, was not always as immune against spread of fire originating within the transformer as are present-day designs. The principal improvements to eliminate the possibility of explosions and fires have been the removal from above the oil surface of unshielded conductors with their corona hazard, and the discontinued use below the oil level in tank construction of solder or other materials of low melting point.

In case a transformer proves defective and an external short-circuit results, it is the opinion of the subcommittee that fire is now a very remote possibility. Oil will not support combustion until its temperature has been raised to the vaporizing point, which is relatively high, and not even in this case unless oxygen is present. In case fire should start, experience indicates that it would be localized to the transformers.

While fires have been known to occur in oil-insulated transformers, any assumption that the use of oil in modern transformers creates a fire hazard is not correct, since explosions have occurred inside of such transformers with no further damage than the breaking of the cover or the distortion of the tank.

The liability of explosions in good present-day construction is further lessened by the fact that the atmosphere above the oil is maintained at ground potential and free from any static stress. This is accomplished by having the metal supporting the leads, or bushing, extend down below the oil level, so that any overvoltage creating a possible discharge must occur under the oil and consequently be smothered, instead of, as in the past, occurring in the gaseous atmosphere above the oil.

Further precautionary steps have been taken recently by at least one large manufacturer in the development of tank construction, in which the tank is completely filled with oil. A small auxiliary tank is provided above the main tank to which it is connected. The oil extends up into this smaller tank and thereby prevents the effect of varying level due to temperature changes from reaching the transformer.

In large units, such as are generally used in indoor installations, the oil-insulated transformers are commonly water-cooled, the oil then operating at a lower temperature than in the self-cooled units. Such water-cooled units are obviously less likely to be damaged by fire from the outside. In present-day practice large self-cooled units are generally installed out of doors, where communicating damage from an external source is very remote.

Several years ago one of the large manufacturers of transformers made some experiments to determine what was necessary to set a tank of oil on fire, and after it was on fire, how difficult it would be to put the fire out. For this purpose about 200 gal. of oil was placed in a tank that had welded corrugated sheet-iron sides, cast solidly into a cast-iron top and bottom. The fire was placed under and around the tank, but the oil could not be ignited until burning waste had been thrown into the tank. When the oil was burning, the flame was extinguished without much trouble by the use of a Pyrene extinguisher. The oil was finally allowed to burn itself out and the tank was found to be still intact and oiltight. The oil did not boil over, but simply burned up from the fire on the surface. The manufacturers state that it is their belief that with a tank of this type, or with a boiler-iron tank, if the oil becomes ignited it will in all probability be confined to the tank and will not boil over or spread oil in the space adjacent thereto. It seems established, therefore, that no unusual fire hazard attends the use of oil-filled electrical equipment.

*Abstract from N. E. L. A. Electrical Apparatus Committee's report, presented at its Forty-Third Annual Convention, Pasadena, Cal., May 18-22, 1920.

Larkin Fund to David Ranken School

The David Ranken, Jr., School of Mechanical Trades, St. Louis, has been left an endowment fund estimated to range in value from $500,000 to $1,000,000 by E. H. Larkin, vice president of the National Ammonia Co., of the same city. The gift consists of Mr. Larkin's stock in the National Ammonia Co., and the fund is to be known as the Larkin Foundation. The income is to be used for the benefit of the school in any way the trustees decide best, but preferably for three things: First, instruction in power-plant operation, heating and ventilation, refrigeration and kindred subjects; second, lectures to mechanics, prospective mechanics and the general public on mechanical subjects; third, as an aid to worthy students who would otherwise be unable to pursue their studies.

Under an endowment approximating $3,000,0000 from David Ranken, Jr., the school was founded in 1907 and opened its doors to students in 1909. Two-year courses are given carpenters, plumbers, painters and decorators, machinists, patternmakers, electricians, auto mechanics and stationary engineers. The school has an active attendance of 300 day and 1,000 night pupils. It is expected that the Larkin fund will be available in about a year's time.

In connection with its latest statistical report covering data as to the cost of coal production, the Federal Trade Commission makes the following statement: "The commission has collected considerable information on the investment necessary for operation in the various districts, derived in part from balance sheets required from operators and in part from information previously reported by them or obtained direct from their books. When such investment figures are available, it then will be possible, after deduction of any sales expense, and income and excess-profits taxes paid, to show the relation which the remainder of the margin bears to the investment."

Notes on the Coal Situation

Many replies have been received by the United States Geological Survey in its census of stocks of coal on hand and anticipated needs. The final date for these reports was indicated in the call as June 12, but the Survey urges that all who have received forms reply, even though they were not able to do so before this date. Co-operation in this is very important for all coal interests.

Coal-land leasing regulations, which were drafted by the conference at the Interior Department about a month ago, have been sent out for examination by various engineers and institutions concerned. Reports are due on June 15, but it is expected that several weeks will elapse before the rules are adopted and promulgated.

Export embargoes both overseas and on Canadian coal and the re-establishment of a fuel-distribution agency of the Government are the two major proposals which have been made recently in the effort to correct coal-supply and coal-traffic evils. Several legislative proposals of export embargo were made during the closing days of the last Congressional session, but none of these prevail, in a number of cases the defeat of such measures being successfully accomplished by the legislators from the coal-producing states.

The Walsh resolution calling upon the Interstate Commerce Commission for information regarding shipments of bituminous coal to tidewater and for other information affecting New England and seaboard supply is being handled by Commissioner Daniels, of the Interstate Commerce Commission. It is believed that most of the information required as to production and traffic is already available from records of the Geological Survey and the Interstate Commerce Commission. An early report is anticipated.

Alaskan coal supply for the Navy may become available before many months have passed, if conditions are found to be favorable to the necessary development work. Commander Darling and other naval officers are now investigating the matter in Alaska preliminary to the decision as to what the Navy will do under the authorization given recently. This authorization provides an appropriation of a million dollars for mine development and a quarter of a million dollars for a coal-cleaning plant.

The Interstate Commerce Commission has given preference and priority to pool coal over non-pool coal, both for cargo and bunker fuel, with reference to all movements to the lower Lake ports. The service order Number 5, issued June 9 to this effect, is intended to arrange for much needed relief with respect to the supply of bituminous coal for the Northwest, which is supplied via the Lakes.

New Publications

ENGINEERING INDEX

The "Engineering Index" for 1919 has just been published by the American Society of Mechanical Engineers. The volume contains over 12,000 references to nearly 700 engineering and allied technical associations. It is an invaluable guide to engineering literature of 1919 and should prove of value to members of the profession.

OPPORTUNITIES FOR THE COMBUSTION ENGINEER

"Opportunities for the Combustion Expert" has just been prepared by the Hays School of Combustion Engineering, of Chicago. It relates in story form the experience of an engineer, pointing out his weaknesses in the first place and then showing how those weaknesses were overcome through a more definite knowledge of the work he is doing every day.

Considerable attention has been paid to the installation of mechanical apparatus to check the amount of fuel used and to prevent as much waste as possible. It is only within the last few years that steps have been taken to lay before the men themselves, who handle the fuel, an opportunity to realize what great opportunities there are for the men who know the essential elements of combustion engineering, and to be able to apply them from a fuel-saving standpoint. The combustion engineer today has a real opportunity.

Copies of this new book will be sent free by the Hays School of Combustion, 1412 South Michigan Ave., Chicago, upon request.

Personals

R. V. Meikle has been appointed chief engineer in charge of construction of the Don Pedro (Cal.) dam and power plant for the Turlock Irrigation District of California.

J. K. Alline, formerly of the Electric appliance Co., of Chicago, Ill., is now Iowa representative for the Packard Electric Co., of Warren, Ohio, manufacturer of transformers and automotive cable.

C. Richard Ward has resigned the position as chief engineer with the New York and Pennsylvania Co., Willsboro, N. Y., to become mechanical superintendent of the Bellman Brook Bleachery Co., Fairview, N. J.

Kenneth B. Millett has resigned as assistant general engineer of the American Thread Co., New York City, to join the organization of the Griscom-Russell Co., New York City, in the capacity of development engineer.

Prof. H. S. Dickerson, for four years professor of mechanical engineering at the University of Missouri, is to take charge of the Mechanical Engineering Department of the Government Institute of Technology at Shanghai, China.

J. A. Housel, who has been associated with the Northern Bolt, Screw and Wire Co., Ltd., of Owen Sound, Ont., Canada, as engineer, for the past eight years, is now affiliated with the Ewing Bolt and Screw Co., of Detroit, Mich., in the same capacity.

William R. Marshall has been appointed manager of the industrial division, New York office of the Westinghouse Electric and Manufacturing Co. to succeed Harlan A. Pratt, who has resigned to become sales manager of the Atlantic Elevator Co., of New York.

Society Affairs

The Electrical Manufacturers Council has opened an office in the Fifth Avenue Guaranty Building, 522 Fifth Ave., New York City. This office will serve as a headquarters for the Council and its work.

The American Society of Mechanical Engineers, Boston Section, will hold its June outing at the Ocean House, Swampscott, Mass., Friday, June 25. An interesting program featuring fat and lean men's races and including tennis, dancing, etc., has been arranged by the committee on entertainment.

The Association of Iron and Steel Electrical Engineers, Pittsburgh and Cleveland District Sessions, will meet in joint technical session, at the Country Club, Warren, Ohio, June 26. Included in the program is a trip to the Trumbull Steel Co., Warren. A paper on "Electric Drives for Steel Strip Mills," by W. P. Rese and A. W. Mohran, of the Trumbull Steel Co., will be read.

The Eastern Geographic Section Meeting of the Pennsylvania Electric Association will meet at the Adelphi Hotel, Philadelphia, Pa., on July 2. The morning session will open at 10 o'clock. The topic of this session will be "Power Factor." Several interesting papers will be presented, followed by five-minute talks on various phases of power factor by operating companies' representatives. The morning session will be followed by a luncheon presided over by John E. Zimmerman, who will introduce the speakers. The subject of the afternoon session is to be "Effect of Unbalanced Load on the System." Short talks by operating companies' representatives will also be included in this session. These talks will cover methods of regulating voltage on unbalanced phases, various methods of phase balancing, balancing large single-phase loads and concrete examples of phase balancing, results obtained and equipment used.

Miscellaneous News

Construction of a Hydro-Electric Plant on the White River, Cotter, Ark., which will involve an expenditure of $15,000,000, is under way by the Dixie Power Co. The plans provide for an initial development of 100,000 hp.

The Massachusetts Institute of Technology and the General Electric Co. have opened a five year course in Co-operative Electrical Engineering. The course will fit students to take leading positions as engineers, scientific experts, and teachers or investigators of electrical science.

The Department of Commerce of the Bureau of Foreign and Domestic Commerce, Washington, in its monthly statement shows the total value of the following exports during April: Pumps and pumping machinery, $1,098,020; refrigerating machinery, $326,828; air-compressing machinery, $512,765.

The American Chamber of Commerce in France has inaugurated an extensive catalog system for the purpose of assisting French purchasers seeking American goods and of assisting the American export trade in general. Information can be obtained from Frank Boole, secretary, American Chamber of Commerce, Paris, France.

The Oil Belt Power Co. is planning expenditures of more than $4,000,000 for the construction of a hydro-electric plant near Eastland, Tex. One of the chief purposes of the plant will be to furnish electric power for drilling and pumping oil wells in the central west Texas fields. It will also provide industries and towns with electrical energy.

Business Items

The Easton Car and Construction Co., New York City, has removed its general offices from 30 Church St. to larger quarters at 50 Church St.

The Merrill Co., San Francisco, Cal., has established a branch office in the Monadnock Building, Chicago. The company also announces that it is now manufacturing the Merco Nordstrom Plug Valve at the plant of the Swenson Evaporator Co., Angola, Ind.

Trade Catalogs

The Cooper Hewitt Electric Co., Hoboken N. J., has published a new booklet illustrating proper methods of industrial illumination by means of photographs of systems actually installed and in use.

"Wellman Mechanical Gas Producer" is the title of Bulletin No. 51, just issued by the Wellman-Seaver-Morgan Co., Cleveland, Ohio. The bulletin is in the form of a text book on gas producers and contains some valuable information. A copy will be sent to any one interested, on request.

COAL PRICES

Prices of steam coals both anthracite and bituminous, f.o.b. mines, unless otherwise stated, are as follows:

ALANTIC SEABOARD

Anthracite—Coals supplying New York, Philadelphia and Boston:

	f.o.b. mines
Pea	$5.85@$6.25
Buckwheat	4.00@ 4.10
Rice	3.00@ 3.50
Barley	2.25@ 2.50
Boiler	2.50

Bituminous—Steam sizes supplying New York, Philadelphia and Boston:

	f.o.b. mines
Cambrias and Somersets, f.o.b. mines net ton	$7.25@$8.00
Clearfields, f.o.b. mines, net ton	6.75@ 8.25
Pocahontas } on cars Providence and	11.00@14.50
New River } Boston; gross ton	11.00@14.50

BUFFALO

Bituminous—f.o.b. mines:

Pittsburgh slack	$6.00@$8.00
Mine-run	6.00@ 8.00
Lump	6.00@ 8.00
Youghiogheny	6.00@ 8.00

CLEVELAND

Bituminous—Retail prices of coal per net ton are as follows:

No. 6 slack	$8.25
No. 8 slack	8.25
No. 8—¾-in.	8.25@ 8.50
No. 6 mine-run	8.25
No. 8 mine-run	8.25
Pocahontas—Mine-run	9.25

ST. LOUIS

Bituminous—f.o.b. mines:

	Williamson and Franklin Counties	Mt. Olive and Staunton	Standard
Mine-run	$3.00@4.00	$3.00@3.50	$4.50
Screenings	3.00@4.00	$3.00@3.50	5.00
Lump	3.00@4.00	3.00@3.50	5.00

Williamson-Franklin rate to St. Louis is $1.10; Other rates 95c.

CHICAGO

Bituminous—Prices f.o.b. mines as per circular of April 1 are as follows: Co. prices vary from 50c. to $1.25

		Freight rate Chicago
Illinois		
Southern Illinois		
Franklin, Saline and Williamson Counties		
	Mine-Run $3.00@$3.10	$1.55
	Screenings 2.60@ 2.75	1.55
Central Illinois		
Springfield District		
	Mine-Run $2.75@$3.00	$1.32
	Screenings 2.50@ 2.60	1.32
Northern Illinois		
	Mine-Run $3.50@$3.75	$1.24
	Screenings 3.00@ 3.25	1.24
Indiana		
Clinton and Linton		
Fourth Vein		
	Mine-Run $2.75@$2.90	$1.27
	Screenings 2.50@ 2.65	1.27
Knox County Field		
Fifth Vein		
	Mine-Run $2.75@$2.90	$1.37
	Screenings 2.50@ 2.60	1.37
Brazil Block	$4.25@$4.50	1.27

New Construction

PROPOSED WORK

Mass., Everett—The Malden Electric Co., Malden, plans to build a local substation here, to cost about $65,000, including $25,000 for equipment. Charles Tenney, 201 Devonshire St., Boston, Engr.

Mass., Fitchburg—The Fitchburg Gas & Electric Co. plans to build an addition to power house which will have a 4,500 kw., 3 phase, 60 cycle, a.c. capacity and include a 5,000 kw. steam turbine and one 750 hp. Bigelow & Hornsby boiler, etc. About $600,000. Charles Tenney, 201 Devonshire St., Boston, Engr.

Mass., Salem—The Salem Electric Light Co. plans to build an addition to its existing power plant on Lafayette St. and install equipment including one 750 hp. Bigelow-Hornsby boiler, etc. About $650,000. Charles Tenney, 201 Devonshire St., Boston, Engr.

Conn., Hartford—The State Highway Dept. plans to install an electrical unit in place of steam plant which will be removed, in connection with the electrification of the Thames River Highway Bridge.

Conn., New Britain—The Amer. Hardware Corp. will build a transformer station at its plant.

Conn., Norwich—The W. S. Finishing Co. is having plans prepared for the reconstruction of a boiler plant here. About $300,000. Day & Zimmerman, 611 Chestnut St., Philadelphia, Pa., Archts. and Engrs.

N. Y., Brooklyn—The Dept. of Pub. Welfare, Municipal Bldg., New York City, rejected all bids for a hospital including a steam heating system, on Cumberland St. Estimated cost, $600,000.

N. Y., Brooklyn—The Packard Motor Car Co., B'way and 61st St., is having plans prepared for a 3 story, 200 x 200 ft. service station and auto showroom including a steam heating system, on Bedford Ave. and Empire Blvd. About $250,000.

N. Y., Buffalo—The Buffalo General Electric Co., Genesee and Washington Sts., had plans prepared for an addition to its power station on Babcock and Hannah Sts. About $25,000.

N. Y., Buffalo—The Niagara Machine Tool Works, 683 Northland Ave., is in the market for a 50 kw., 115 volt belted direct generator.

N. Y., Buffalo—James Storer, Secy. of the Bd. Educ., New York Telephone Bldg., will receive bids until June 25 for furnishing and installing boilers, boiler equipment, pumps, piping, heat control regulators, fans, motors, etc., in primary school 21, Amherst St. and Park Lake Ave., elementary school 21, Hertel Ave. and Camden St., elementary school 9, Polar Ave. and Doat St., Associated Buffalo Architects, Inc., 250 Delaware Ave., Archts.

N. Y., Dunkirk—The Niagara & Erie Power Co., Marine Bank Bldg., Buffalo, has made application to the Pub. Serv. Comn., for permission to build an addition to its power plant here.

N. Y., New York—A. L. Erlanger, 214 West 42nd St., plans to construct two 3 story theatres including a steam heating system on West 44th St. About $850,000. F. R. Anderson, 214 West 42nd St., Archt. and Engr.

N. Y., New York—The New York Edison Co., Irving Pl. and 13th St., is having plans prepared for a substation on Elizabeth, near Canal St.

N. Y., New York—The New York Telephone Co., 15 Dey St., plans to build an addition and make alterations to the present telephone exchange building including a steam heating system, on 146th St. and Convent Ave. About $500,000.

N. Y., Springville—E. B. Kuhn, Secy. of the Bd. Educ. of the Griffith Institute, will soon award the contract for furnishing material and installing a steam heating plant in the school here.

N. J., Dover—The Ordnance Dept. has received bids for a power house for the general operating service at the Picatinny Arsenal, here.

N. J., Newark—The Bd. Educ., City Hall, received bids for installing a steam heating system in the proposed school addition on Alexander St., from J. H. Cooney, 210 North 4th St., $36,542; Fred P. Merhle, 533 Central Ave., $35,972, and in the vocational school on 1st and 2nd Aves., from J. H. Cooney, 210 North 4th St., $173,840; J. H. Nellis, 884 Sanford Ave., Trenton, $174,360. Noted May 25.

N. J., Newark—M. Straus & Sons, 508 Frelinghuysen Ave., had plans prepared for a power house at its leather works here. Two boiler units will be installed in connection with other equipment. About $30,000.

N. J., Perth Amboy—The Perth Amboy Dry Dock Co., Broad St., plans to install electrically operated pumping machinery, valves, etc. for the operation of the new dry dock at its plant here.

N. J., Rahway—The Middlesex Water Co. has been ordered by the Pub. Utility Comn. to install equipment by July 15 at its plant here, which will provide for a daily capacity of 4,000,000 gal.

N. J., Westfield—Runyon & Carey, Engrs., 845 Broad St., Newark, will soon award the contract for a heating and ventilating system, 2 cast iron boilers, ventilating fans and units, etc., in the Washington School here, for the Bd. Educ.

Pa., Philadelphia—The Enterprise Mfg. Co., 3rd and Dauphin Sts., had plans prepared for the construction of a power house at its hardware manufacturing plant on Bodine St. About $28,000.

Pa., Philadelphia—The Hale & Kilbourne Corp., 18th and Lehigh Sts., manufacturer of iron and steel products, had plans prepared for an addition to its power plant here. Boilers, stokers and auxiliary equipment will be installed in same. About $60,000.

Pa., Pittsburgh—The Prest-O-Lite Co., 5528 Baum Blvd., is receiving bids for a 30 x 36 ft. compressor building, a 15 x 33 ft. boiler house addition, etc., on Lincoln and Tabor Sts.

Pa., Pittsburgh—The West Penn Power Co. plans to extend its transmission system.

Md., Baltimore—Haskell & Barnes, Archts., 301 North Charles St., will receive bids until June 30 for an 8 story, 100 x 186 ft. warehouse including a steam heating system on Guilford Ave., Saratoga and David Sts., for the Whitaker Paper Co., 415-37 Guilford Ave. About $500,000.

Md., Baltimore—Samuel T. Williams, 223 North Calvert St., is in the market for a stiff-legged or guyed derrick, about 35 ft. boom, to lift 1½ tons (used), a steam driven, 2 drum hoist to operate derrick (used) and a house-heating boiler and radiation for heating 2,500 sq.ft. floor space, etc.

Md., Easton—The Borough Council plans to install new electric operated centrifugal pumps at the waterworks here with capacity varying from 150 to 600 gal. per minute.

D. C., Washington—The Bureau of Yards & Docks, Navy Dept., plans to install a new boiler, etc., in the heating plant at the Naval Observatory here. About $10,000.

Va., Lorton—The Dist. of Columbia Comrs., 50 District Bldg., Wash., D. C., will receive bids until July 5 for electric generating set, exciter, switchboard, etc., for the central power plant at the D. C. institutions here.

Va., Richmond—The Arrow Laundry Co., 117 East Main St., is in the market for a 100 hp. steam engine, shafting and belting, etc.

Va., Richmond—The Virginia Carolina Rubber Co., Real Estate Exch. Bldg., is in the market for all machines used in the manufacture of auto tires and accessories including an engine, boiler, shafting and belting. Mr. Bell, Pres.

O., Cleveland—The Bd. Educ. plans to build a 1 story school for crippled children including a steam heating system. About $350,000. F. Hogan, Dir. W. R. McCormack, East 6th St. and Rockwell Ave., Archt. A bond issue will be voted upon for the project.

O., Cleveland—The Bd. Educ. plans to build a 3 story school including a steam heating system on Diana and Darley Aves. About $600,000. W. R. McCormack, East 6th St. and Rockwell Ave., Archt.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., plans to construct a school addition to the Rickoff School on Kinsman Rd., cost, $350,000; and a school on Spring Rd., cost, $1,000,000. Plans include steam heating systems. W. R. McCormack, Archt.

O., Cleveland—The city received bids for furnishing and installing 2 pressure booster pumps and 23 hydraulic operated sluice gates from the Coffin Valve Co., Wade Bldg., $34,140; J. L. Skeldon Eng. Co., Rockefeller Bldg., $68,136.

O., Cleveland—The city is having plans prepared for two 8,000,000 and one 4,000,000 gal. pumps. About $25,000. E. Shattuck, Clerk.; G. B. Gascoyne, Engr.

O., Ravenna—The McGrath Tire & Rubber Co., 1836 Euclid Ave., Cleveland, had plans prepared for the construction of a 3 story, 100 x 300 ft. factory and a 30 x 50 ft. boiler house. About $125,000. Donald C. Smith, 4500 Euclid Ave., Cleveland, Archt. and Engr. Noted May 3.

O., Toledo—The city will soon award the contract for a 30 x 116 ft. pumping station. Equipment including switchboard, electric crane, four 300 hp. motors, one 200 hp. motor, two vacuum pumps, five centrifugal pumps, etc., will be installed in same. Fuller & McClintock, B'way, New York City, Archts. and Engrs.

Mich., Bay City—The Wildman Rubber Co., 816 Book Bldg., Detroit, has purchased a site along the Saginaw River and plans to build a tire plant on same. Plans include a power plant. About $1,000,000.

Wis., Platteville—The Peacock Cheese Co., South 12th and Jefferson Sts., Sheboygan, has purchased a site and plans to construct a cheese warehouse and cold storage plant on same.

Kan., Mt. Hope—The Borough Council will build a new electric power plant. About $15,000.

Kan., Paola—The City Clerk will soon award the contract for repairing the present pumping station, water mains, etc. Black & Veatch, Interstate Bldg., Kansas City, Mo., Engrs.

Mo., St. Louis—The Majestic Mfg. Co., 2014 Morgan St., is having plans prepared for a 2 story factory, including several electric motors. About $30,000. J. H. Lynch & Son, Dolph Bldg., Archt. and Engr.

Ore., Burns—The city has retained Louis C. Kelsey, Consult. Engr., Portland, to prepare plans and supervise the construction of a lighting plant.

Ore., Corvallis — Edmund Bergholtz, Archt., Spalding Bldg., Portland, will receive bids until Sept. 1 for a 4 story, 75 x 100 ft. hotel. About $330,000. Heating contract will be sublet. Owner's name withheld.

Ore., Enterprise—The Enterprise Mercantile & Milling Co. plans to construct a small electric lighting plant at its flouring mill ere, which will be operated by water power. G. W. Hyatt, Pres.

Ore., Portland—Houghtaling & Dougan, Archts., 329 Stark St., will receive bids until October 1 for a 5 story, 100 x 150 ft. temple on 11th and Alder Sts., for the Elks Lodge. Contract for heating, etc., will be sublet. About $700,000.

Cal., Berkeley—The Bd. Educ., 2133 Allston Way, will receive bids until June 29 for furnishing deep well pumping head, motor, pipe electric power connections, belts, foundations, etc., at each of 3 schools.

Cal., San Francisco — The Bureau of Yards & Docks, Navy Dept., Wash., D. C., will receive bids until June 30 for furnishing and installing refrigeration equipment in the Industrial Bldg., here. About $50,000.

Cal., Stockton—The Bd. Supervs. plans to construct buildings and improvements for the Agricultural Park here. Complete scheme to include machinery hall, auto exhibit building, electric light and power plant, etc. About $1,000,000. Wright & Satterlee, Archts.

Que., Grosse Isle—The Dept. of Pub. Wks., Ottawa, will soon receive bids for new boilers for the Quarantine station here, at $29,882.

Que., Montreal—The city plans to install an electrically driven pumping plant, provide for the initial installation of five 30,000,000 gal. pumps and space for 3 additional pumping units. Two of these pumps have been ordered and are already in operation. About $850,000.

Ont., Toronto — The Bd. Educ., College St., plans to construct a 3-story technical school, including a vacuum steam heating system with an electric driven mechanical ventilating system. About $400,000. Address Dr. McKay, Central Technical School, College St.

Ont., Toronto — The Canada Creosoting Co., 1006 Canadian Pacific R.R. Bldg., plans to construct a plant and is in the market for tanks, cylinders, pumps, boilers, motor generators, etc.

Ont., Toronto—The Muskoka Quarries, Ltd., 271 Macpherson Ave., plans to install a complete stone crushing plant with electrical motors and equipment.

Ont., Woodstock — The town has purchased a site on Ingersoll Ave., and plans to construct a substation on same. Electric supplies, including switching apparatus, transformers, etc., will be installed in same. About $35,000. Mr. Archibald, Engr.

CONTRACTS AWARDED

Vt., Brattleboro—The C. F. Church Mfg. Co., Willimansett, Mass., has awarded the contract for a 1 story main building, 1 story boiler house, etc., to E. F. Carlson Co., 244 Main St., Springfield, Mass., at $80,000.

Conn., Hartford—The Hartford Fire Insurance Co., 125 Trumbull St., has awarded the contract for a 1 story, 90 x 120 ft. boiler house on Asylum St., to Marc. Eidlitz & Sons Co., 30 East 42nd St., New York City. About $150,000.

Conn., Waterbury—The Connecticut Light & Power Co., 111 West Main St., has awarded the contract for a 2 story addition to its power station on Freight St., to D. Wooster, 39 Harvard St. About $10,000.

N. Y., Long Island City—The Atlantic Macaroni Co., Inc., 295 Vernon Ave., has awarded the contract for a 93 x 400 ft. factory including a steam heating system on Vernon Ave. and 14th St., to the White Constr. Co., Inc., 95 Madison Ave., New York City. About $1,000,000.

N. Y., New York (Bronx Borough)—V. Vivadou Perfumery, Inc., Times Bldg., has awarded the contract for a group of factory buildings, including a steam heating system, on the Southern Blvd. and Leggett Ave., to J. M. Brady, 103 Park Ave., at $1,000,000.

N. Y., New York—The 562 5th Ave. Corp., 1552 B'way, will build an 11 story office building including a steam heating system, on 46th St. and 5th Ave. Work will be done by day labor.

N. J., Atlantic City—The Ritz Carlton Linnard Co., c/o Warren & Wetmore, Archts. and Engrs., 10 East 47th St., New York City, has awarded the contract for a 130 x 310 ft. hotel, including a steam heating system, on Illinois Ave. and the Board Walk, to Thompson & Starrett, 49 Wall St., New York City. About $2,000,000.

N. J., Newark—Samuel Jones & Co., 37 McClellan St., has awarded the contract for a 1 story, 30 x 80 ft. factory and a 40 x 40 ft. boiler house, to Charles R. Heddon Co., 763 Broad St., at $25,000.

N. J., Newark—The Schofield Oil Co., Ave. R, has awarded the contract for a 1 story, 31 x 52 ft. power house on Railroad Ave. and Passaic St., to E. M. Waldron Co., 885 Broad St. About $30,000.

N. J., Trenton—The Bergounan Rubber Corp. of Trenton has awarded the contract for three factory buildings including a steam heating system, on Whitehead Rd., to the Farrall Constr. Co., 53 West 39th St., New York City, at $250,000.

Md., Baltimore—The Mayor and the City Council, City Hall, has awarded the contract for a 3 story, 64 x 121 ft. public school including a steam heating system, on Poplar Grove St., to the Standard Constr. Co., 1713 Sansome St., Philadelphia, Pa., at $399,000.

Ala., Florence — The U. S. Engineer's Office, Wash., D. C., has awarded the contract for 4 hydraulic turbines to William Cramp & Sons, Ship & Engine Bldg., Philadelphia, Pa. $519,600.

O., Akron—The Akron Theatre Co. c/o Frank, Wagner & Mitchell, Archts., 602 Penn Title & Trust Bldg., has awarded the contract for a 3 to 6 story, 13 x 160 ft. theatre, arcade and commercial building including a steam heating system, on South Main St., to the Carmichael Constr. Co., 524 Hamilton Bldg., at $500,000.

O., Cleveland—The Cleveland Ry. Co., Leader-News Bldg., has awarded the contract for a 1 story, 47 x 64 ft. electric substation on East 99th St. and St. Clair Ave. to the Gaylord W. Feaga Co., Citizens Bldg., and for the installation of two 1500 kw. rotary converters with blowers and generator sets and other equipment to the Westinghouse Mfg. Co., Swetland Bldg. Noted May 25.

O., Middletown—The Colin Gardner Paper Co. has awarded the contract for a 1 story, 50 x 80 ft. turbine power plant, to the Ferro Concrete Constr. Co., Richmond and Harriet Sts., Cincinnati. $45,000.

O., Willoughby—The Zenith Tire & Rubber Co., 450 Leader-News Bldg., Cleveland, has awarded the contract for a 1 and 3 story, 100 x 620 ft. warehouse, factory and boiler house on Main St., to William Dunbar Co., 8201 Cedar Ave., Cleveland. Two 300 hp. boilers will be installed in same. About $750,000. Noted Oct. 28.

Mich., Detroit—The Detroit Graphite Co., 12th and Fort Sts., has awarded the contract for a 5 story, 61 x 92 ft. office building including a steam heating system, on 12th St., to the Max Batholomaei Son & Co., 466 East Warren Ave.

Ark., Arkadelphia—Quichita College has awarded the contract for three 3 story school buildings including a steam heating system, to J. D. Brock, at $250,000.

Kan., Norton—The city has awarded the contract for a commissary building, power house addition, concrete coal bunker, dam and addition to sewage treatment plant, to Green & Rickey, Norton, for a 100 hp. boiler, hot water tank, water mains, hydrants and other miscellaneous heating and plumbing work, to Patterson & Co., Topeka, and for an engine and generator, etc., to the Machinist & Electric Co., Topeka.

Mo., St. Louis—D. R. Francis, 214 North 4th St., has awarded the contract for installing a steam heating system in the proposed mercantile building at 1529-35 Washington Ave., to the Eichler Heating Co., Railway Exch. Bldg.

Tex., Galveston—The Galveston Wharf Co. has awarded the contract for the installation of 6 high density cotton compresses with overhead monorail conveyance machinery for serving all piers along the Galveston Wharf front from Pier 10 to 41, to J. H. W. Steele Co., 220 21st St. About $500,000.

Cal., Los Angeles—The Bd. Educ., 731 Security Bldg., has awarded the contract for the installation of a steam heating system and boiler plant in the proposed 1 and 2 story, 132 x 220 ft. school on East 7th St., to Thomas Haverty Co., 8th St. and Maple Ave., at $12,585. Noted June 8.